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FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION

APRIL 1965

HUGO FISHER
Administrator
The Resources Agency

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Director
Department of Water Resources

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DEPARTMENT OF WATER RESOURCES
P. O. BOX 388
SACRAMENTO

February 3, 1965

Honorable Edmund G. Brown, Governor,
and Members of the Legislature
of the State of California
State Capitol
Sacramento, California

Gentlemen:

This report culminates an investigation of the general quality of surface and ground water supplies of the Fresno-Clovis Metropolitan Area. Of particular concern was the present quality of water in those parts of the study area where degradation of water quality had been revealed by former investigations.

Although there were indications of lower quality ground water in the vicinity of the Fresno Sewage Treatment Plant, the present investigation revealed that the general quality of ground and surface water in the Fresno-Clovi Metropolitan Area is excellent at the present time. One matter of some concern however, was the possibility of a change occurring in the ground water gradient Although the gradient is now generally from northeast to southwest, a steady annual lowering of the ground water table under the heart of Fresno's downtown area together with ground water recharge owing to land disposal of large quantities of effluent from the Fresno Sewage Treatment Plant have created an almos level water table near the plant. If these trends continue, a reversal of grou water flow may occur, and ground water could flow from the vicinity of the sewa treatment plant toward the center of Fresno.

The bulletin recommends that sound water conservation practices be observed to ensure that the ground water gradient remains in the southwesterly direction, that sanitary and disposal facilities be expanded so that all individual septic tanks and leach wells could be eliminated, that standards for the construction or abandonment of water wells be established and enforced by Count ordinance, that all existing and future water wells in the Fresno-Clovis Metropolitan Area be registered with a duly authorized agency, and that existin monitoring programs should be expanded to frequently determine the ground water level and the water quality, with even more frequent monitoring in areas of apparent or potential degradation.

Sincerely yours,

William E. Warne

Director

ACKNOWLEDGMENTS

We wish to express our appreciation and gratefully acknowledge the valuable assistance, cooperation, and data which were received from various federal, state, county, city, and private agencies and individuals in the Fresno-Clovis Metropolitan Area.

Special mention is made of the following:

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Fresno County-City Chamber of Commerce

City of Fresno

City of Clovis

Fresno Irrigation District

Fresno Municipal Flood Control District

Fresno County Waterworks Districts

Calwa County Water District

Pinedale County Water District

State of California
The Resources Agency
Department of Water Resources

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SAN JOAQUIN VALLEY BRANCH

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CHAPTER I. INTRODUCTION

California's tremendous growth in population, as well as production of industrial and agricultural products, has resulted in a corresponding increase in the demand for water. In the agriculturally developed San Joaquin Valley, where the quantity of available surface water is not adequate to satisfy demands, ground water supplies have had to be extensively developed and are now the principal source of supply for the Fresno-Clovis Metropolitan Area.

Population expansions burden municipalities and communities with the problem of expanding water and sewerage systems. The new construction and expansion of these facilities are based upon economics and fairly well standardized engineering practices, but the ultimate disposal of wastes may not be as easily solved and frequently becomes involved with esthetic values and public health considerations.

Disposal of treated wastes may not be a problem for a city, community or industry located in the vicinity of a large perennial river; however, in the San Joaquin Valley the few perennial rivers contain such low flows during the summer months that they are inadequate for the assimilation of wastes. Consequently, waste water effluents are applied to the land surfaces for disposal by evaporation, percolation, and utilization by crops.

The population expansion in the Fresno-Clovis Metropolitan Area has caused a greater concentration of wastes at the area's disposal sites, thereby increasing the possibility of ground water degradation.

Degradation of surface water quality is readily detectable by conventional monitoring techniques, but serious and often irreparable damage may result in a ground water aquifer before being detected. Furthermore, the movement of ground water usually proceeds at such a slow rate that the cause may have existed many years before the damage is evident or detected.

Authorization

The current population growth in conjunction with previous problems in and around Fresno prompted a need for a general water quality investigation to determine present water quality conditions. This investigation was conducted pursuant to Section 229 of the California Water Code which states:

> "The department (of Water Resources) either independently or in cooperation with any person or any county, state, federal or other agency, to the extent that funds are allocated therefor, shall investigate conditions of the quality of all waters within the State, including saline waters, coastal and inland, as related to all sources of pollution of whatever nature and shall report thereon to the Legislature and to the appropriate regional water pollution control board annually, and may recommend any steps which might be taken to improve or protect the quality of such waters."

Area of Investigation

The area of investigation encompasses, with minor deviation, the Fresno-Clovis Metropolitan Area, as designated by the U. S. Bureau of Census. It is one of eight "standard metropolitan areas" in the State of California.

Geographical Location, Boundaries and Size

The City of Fresno, located in Fresno County, is in the middle of the San Joaquin Valley and near the geographical center of the State. The metropolitan area, which consists of approximately 232 square miles, extends from American Avenue on the south for 13.5 miles to Herndon Avenue on the north and from Rolinda Avenue on the west for 17.4 miles to DeWolf Avenue on the east. The area includes the communities of Malaga, Calwa, and Pinedale, and the cities of Fresno and Clovis, with an aggregate population of approximately 280,000. The area under consideration is shown on Plate 1.

Topography

The topography of the area is characteristic of the San Joaquin Valley floor with miles of nearly level terrain situated between the Coast Range, approximately 50 miles to the west, and the Sierra Nevada foothills, approximately 15 miles to the east. This same terrain prevails from the northern portion of the Sacramento Valley, near Redding, to the southern portion of the San Joaquin Valley, just south of Bakersfield, a distance of 425 miles.

The general slope of the land surface in the vicinity of Fresno is represented by a slight westerly decline of four and one-half feet per mile.

Climate

The climate of the Fresno-Clovis Metropolitan Area and the surrounding valley is dry and semi-desert in character. During the hottest months, daily maximum temperatures range from 75° to 115°F. with accompanying low humidity and noticeable wind. The long growing season, occurring generally between April and November, together with mild winters result

in a highly productive agricultural environment. Precipitation, which seldom occurs during the summer months, averages approximately 11 inches annually.

Economy

The economy of the San Joaquin Valley is based mainly on agriculture with Fresno-Clovis Metropolitan Area forming the hub of the valley and thereby conducting a sizable portion of the regional trade. Fresno County has led the nation since 1950 in the value of its agricultural products. It ranks number one in the nation in the production of grapes, raisins, wines, freestone peaches, figs, cantaloupes, barley, and certified alfalfa seed, and ranks second in cotton. Nut, fruit, livestock, and poultry production rank high in the total value of the county's output.

Major agricultural products and associated industries of the metropolitan area include fruit, nut, and vegetable processing and packing; wines, brandies, and spirits; cotton ginning and compressing; poultry and meat dressing and packing; and dairy products. Numerous nonagricultural products are also produced in this area but many of these support agriculture either directly or indirectly.

Objective and Scope of Investigation

The objective of this investigation is to ascertain the general quality of surface and ground water supplies and specifically determine existing quality in areas where degradation was revealed by past investigations. To achieve this objective it was necessary to review available information and collect additional data on geology, hydrology, waste disposal, and water quality.

Sufficient information was available from previous reports, water well drillers' logs, exploratory borings, and other agencies to enable the department to describe the geology underlying the area, a brief summary of which is included later in this report.

The hydrologic studies conducted in connection with this investigation were concerned with the occurrence, distribution, and movement of surface, ground, and waste waters. Information on ground water levels was obtained from the City of Fresno, Fresno County Waterworks Districts in the area, and the Fresno Irrigation District. This information was supplemented by additional measurements made during the course of this investigation. Surface water measurements were obtained from the Fresno Irrigation District.

The survey of waste discharges was conducted by visiting municipal sewage treatment plants and industrial plants which utilize various methods of disposal. The quantity of waste water and the method of treatment and disposal were noted, and samples of discharges were collected for analyses of chemical properties.

Wells, specifically those in the vicinity of waste discharges or in unsewered residential areas, were checked for the presence of nitrates and alkyl benzene sulfonate (ABS). In ground water, the occurrence of ABS and high nitrates, particularly in combination, is considered to be indicative of possible sewage pollution. Wells in which initial water analyses indicated possible degradation were resampled, and the suspected source of degradation investigated.

Recommendations for correcting undesirable and potentially undesirable water quality conditions in the Fresno-Clovis Metropolitan Area are included in the conclusion of this report.

Related Investigations and Reports

Reports and publications utilized during this investigation are listed in Appendix A. Direct reference to a particular publication or report is indicated by a number in parentheses, for example (1).

Two reports prepared in past years by the Department of Public Works, Division of Water Resources, at the request of the Central Valley Regional Water Pollution Control Board were of particular value in this investigation: "Investigation of Cooling Water Return, City of Fresno," December 1952 (7); and "Effect of Waste Discharges from the Pacific Fruit Express Ice Plant and the Southern Pacific Zeolite Water Softening Plant, Fresno County," December 1953 (5).

CHAPTER II. WATER SUPPLY AND QUALITY

The municipal, domestic, and industrial water supply for the Fresno-Clovis Metropolitan Area is obtained entirely from ground water. Numerous agencies supply the region with water, and, in addition, private wells are maintained on many farms and residences.

The City of Fresno, which pumped an annual average of 50 million gallons per day (mgd) during 1963, is the largest water supplier in the metropolitan area. Areas not contained within the city boundaries of Fresno or Clovis receive their water from either public agencies or private companies, or from individual domestic and irrigation wells. There are 32 actively operating county waterworks districts that are the primary suppliers of water in the unincorporated area. A list of municipal and domestic ground water suppliers in the area is included in Table 1.

On the basis of available information, it is estimated that an annual average quantity of 140 to 150 mgd is pumped from ground water underlying the metropolitan area, and during the hottest days of summer this figure is at least doubled.

Irrigation requirements are mainly fulfilled by surface water; however, ground water is used as a supplement in the outlying reaches. Fresno Irrigation District encompasses the metropolitan area and interlaces the area with a system of canals and ditches to convey Kings River water for irrigation and ground water recharge. This district is one of 28 organizations utilizing the Kings River flow. The quantity obtained depends on the water available and thus varies considerably from year to year. In 1963, approximately 490,000 acre-feet were received; previous annual allotments have ranged from 100,000 to 600,000 acre-feet.

TABLE 1

MUNICIPAL AND DOMESTIC GROUND WATER SUPPLIERS
FRESNO-CLOVIS METROPOLITAN AREA
1962

Agency	Population Served 1/	Number of Wells	Quantity (mgd) 2/		
			Maximum	Mean	Minimum
City of Fresno	151,600	62	110	50 3/	20
City of Clovis	8,000	8	1.5	1.3	1.0
Pinedale County Water District	4,000	4	0.39	0.3	0.22
Calwa County Water District	4,400	5	1.34	0.9	0.4
Fresno County Water Works Districts					
No. 1	2,700	6	3.0	1.6	0.29
No. 2	1,080	3	0.78	0.4	0.07
No. 4	6,050	7	3.6	2.0	0.45
No. 5	1,110	-	0.75	0.4	0.09
No. 8	3,400	5	3.42	1.8	0.28
No. 10	2,490	4	2.7	1.5	0.28
No. 12	1,840	3	1.75	0.9	0.14
No. 13	1,190	2	1.04	0.6	0.12
No. 14	780	2	0.38	0.2	0.06
No. 16	1,500	2	0.9	0.5	0.1
No. 19	970	4	1.0	0.5	0.12
No. 21	1,400	5	2.09	1.1	0.24
No. 24	820	3	0.75	0.4	0.07
Nos. 7, 11, 17, 22, 23, 25, 27, 28, 32, and 36	3,270	-	-	1.6	-
Nos. 3, 15, 29, 34, and 37	1,710	-	-	0.8	-
Nos. 6, 9, 20, and 26	1,400	-	-	0.7	-
Private Companies					
Bakman Water Company	2,100	7	0.7	0.4	0.2
Highway City Water System	2,000	3	0.5	0.3	0.2
Kavanagh Vista Water Company	1,800	9	1.1	0.7	0.2
Northeast Gardens Water Company	1,500	3	1.5	0.8	0.2
Additional small private water companies plus farms and individual residence wells	73,000	-	-	75 4/	-

1/ 1960 census or estimates from state or local sources
2/ Million gallons per day

The City of Fresno has a contract with the United States Bureau of Reclamation to receive up to 60,000 acre-feet of Class 1 water per year from the San Joaquin River at Millerton Lake. Delivery of this water has not yet begun but plans are being formulated whereby the water will be used by the City as a supplemental supply and/or used to recharge the ground water aquifer. Under a proposed contract with the Bureau, Fresno Irrigation District shall accept any portion of the water not used by the City of Fresno and may receive up to an additional 75,000 acre-feet of Class 2 water per year. The terms "Class 1 water" and "Class 2 water" are described in the proposed contract as follows:

1. "Class 1 water" shall mean that supply of water at Millerton Lake which, subject to certain contingencies, will be available for delivery through the Friant-Kern and Madera Canals and the San Joaquin River as a dependable water supply during each irrigation season.

2. "Class 2 water" shall mean that supply of water which becomes available in addition to the supply of Class 1 water and which because of uncertainty as to its availability and time of occurrence will be undependable in character and will be furnished only if, as, and when said water is available as determined by the United States.

Fresno Irrigation District and Fresno Metropolitan Flood Control District are embarking on a program of acquisition and development of ponding sites for purposes of ground water recharge, retention of overflow spill water, and flood control. Approximately 150 acres of ponding area have been acquired and developed by the irrigation district. Fresno Metropolitan Flood Control District has an ultimate plan to acquire approximately 1,000 acres, in 10-acre plots, to be used for the retention of storm waters and ground water recharge. Arrangements are being made whereby some of these ponding areas can be utilized by both agencies at various times of the year.

Water quality criteria adopted by the Department of Water Resource were employed to evaluate water supplies for domestic, industrial, and irrigation uses. These criteria are presented in Appendix B.

Surfacc Water

The major streams and canals in and around the metropolitan area are delineated on Plate 2. A tabulation of surface water analyses is shown in Table D-1, Appendix D.

Surface Water Quality

Evaluation of surface water samples collected during the course of the investigation indicated Class 1 irrigation water, with the exception of Fancher Creek, which is located in Township 13 South, Range 22 East, just east of the Fresno-Clovis Metropolitan Area. Analysis of a sample taken from Fancher Creek in May 1963 indicated comparatively high concentrations of constituents, especially sulfates and dissolved solids. In November 1963 when the water was again flowing, another sample was obtained from Fancher Creek and tested by a field kit for sulphates, total hardness and pH values. Values of sulphates and pH were comparable to those found in samples of surface water in other streams of the area. Total hardness was still much higher, although not as high as revealed by analysis conducted in May 1963.

The remaining surface water in the area is diverted from the Kings River below Pine Flat Dam through the canal system of Fresno Irrigatio District and reflects the excellent quality of the Kings River. Both the Kings and San Joaquin Rivers as they emerge from the Sierra foothills carry water of comparable character and quality which remains fairly uniform throughout the year.

Ground Water

Locations of water wells used in this investigation are plotted on Plate 6. Table D-2, Appendix D, is a tabulation of the analyses of water samples obtained from water wells during the investigation.

Ground Water Geology

A geologic study of the Fresno-Clovis Metropolitan Area was conducted to determine directions of ground water movement and to provide background information by which water quality data could be evaluated. Three geologic sections prepared from available well drillers' logs are shown on Plate 3; the locations of these sections are shown on Plate 5.

The Fresno-Clovis area is underlain by both young and old alluvium which in turn rests upon the Friant formation. Areal geology as shown on the U. S. Bureau of Reclamation Reconnaissance Geologic Map of the Fresno-Kingsburg area is included in this report on Plate 4.

The young alluvium is composed of deposits on flood plains from minor drainages north of the Kings River. It is located predominantly in the northeastern section of suburban Fresno and extends to the Clovis area where it divides to the north and east following the courses of Dry Creek and Dog Creek. Some additional young alluvium derived from Redbank Slough is found to the east of Fresno.

The old alluvium underlying the remainder of the Fresno area consists of sands, silts, gravels, and clay. Some parts of this old alluvium, particularly the deeper portions penetrated by deep wells north of Fresno, may be the upper portion of the Friant formation.

The Friant formation, consisting of sands, silts, gravels, pumice, and rhyolitic material, does not outcrop in the Fresno-Clovis Metropolitan Area. Drillers familiar with the area have frequently noted a marker bed

of pumice or pumicite in deeper wells. Certain hard zones encountered at depth and logged by many drillers as "hardpan" may represent the upper Friant formation.

The alluvial deposits of the Fresno area dip southwestward at approximately the same attitude as the surface topography. The old alluvium north of Fresno and south of Pinedale appears to have a southward dip locally. Water-bearing materials are predominantly sands, but some water is obtained from a zone of gravel in the northern portion of the city. The sand aquifers appear to be fairly continuous and are largely interconnected throughout most of the area. However, certain clay and sandy clay zones appear to have localized continuity and thus may act as partial barriers to downward percolation of ground water. It should be recognized that the apparent continuity may be an illusion caused by correlations based on a limited number of deep wells. Generally, the more continuous clay beds occur well below the water table and are penetrated only by the deeper municipal wells. The principal gravel aquifer encountered by wells in the northern part of the city appears to be an older stream channel deposit, possibly an older channel of the San Joaquin River. This deposit, probably somewhat sinuous, intersecting, and interconnected in configuration, is shown to have a southerly gradient in the geologic section along Palm and Walnut Avenues.

Geologic factors which govern ground water conditions in the Fresno-Clovis Metropolitan Area are:

1. The gently southwestward dipping structure of the alluvial deposits underlying the area.
2. The complex interconnected nature of the permeable units within these deposits.

3. The existence of or lack of continuity in the less permeable members of this alluvium.
4. The high permeability of the young alluvium in the recharge areas to the east and northeast.
5. The development of zones of "hardpan" or clay in the soils of the old alluvium which may slow or divert recharging waters in some areas.

Ground Water Occurrence

Historically, ground water has been found throughout the Fresno area at relatively shallow depths. Intensive use of this readily available supply has caused the water table to decline through the years so that it now averages about 70 feet in depth beneath a large portion of the City of Fresno. During the last ten years the decline of water levels has averaged three feet per year. Plate 5 illustrates ground water elevations in and around the metropolitan area (spring 1963).

In 1915 the water table beneath the Fresno-Clovis area had a fairly even southwesterly gradient averaging about eight feet per mile (0.0015). Although the regional water table still maintains its general southwesterly gradient, heavy pumping in the Fresno area, together with insufficient recharge, has modified the historical configuration. The gradient now dips south from Pinedale toward the heart of Fresno and nearly due west from the City of Calwa. Between Fresno and Clovis the gradient remains southwesterly but has increased from eight feet per mile to about 20 feet per mile. Southwest of Fresno the gradient has become very flat with a minimum of about one-half foot per mile (spring 1963). Should this trend continue it is possible that a "pumping depression" may eventually develop beneath Fresno, resulting in a reversal of the

gradient in the area southwest of the city. Minimum and maximum gradients occurring in the metropolitan area and predominant direction of movement of ground water in each township, are presented in Table 2.

Specific yields of the water-bearing formations in the Fresno-Clovis area are given by depth zones in the Tulare Basin Report (6). From these yields the corresponding permeabilities may be ascertained by use of a specific yield-permeability curve. Average permeabilities for townships in the Fresno-Clovis area were developed using this method and are also included in Table 2. In the vicinity of Fresno average permeabilities vary from 135 to 820 gallons per day per square foot. The average for the Fresno-Clovis Metropolitan Area is approximately 620 gallons per day per square foot. The highest local permeabilities were found in the channels and fans of the small active drainages such as Dry Creek, Dog Creek, Fancher Creek, and Redbank Slough; the highest average permeability was in Township 14 South, Range 21 East, and reflects the high permeability of the young alluvium of Fancher Creek and Redbank Slough.

A layer of hardpan at a depth of five to ten feet is frequently encountered in the old alluvium found throughout most of the Fresno area. Although downward movement of water is impeded by the hardpan, percolation does occur at an estimated rate of one to three gallons per day per square foot. In certain suburban areas, percolation is enhanced by septic tank leach wells which penetrate the hardpan to reach underlying, more permeable sands.

Most recharge occurs in the Fresno-Clovis area through the young alluvium deposits of intermittent streams entering the area from the east, through percolation and infiltration from ponds associated with sewage treatment facilities, and through the canal systems and ponding sites

TABLE 2

GROUND WATER AQUIFER CHARACTERISTICS
FRESNO-CLOVIS METROPOLITAN AREA

Township[1]	Direction of Ground Water Movement	Specific Yield - Percent[2] Depth in feet					Permeability (gals/day/sq.ft) Depth in feet					Gradient in Feet per Foot	
		0-50	50-100	100-200	200-300	Ave.	0-50	50-100	100-200	200-300	Ave.	Min.	Max.
12S/21E	W, SW	9.3	10.3	10.7	8.2	9.56	425	505	620	340	448	0.0015	0.0095
12S/22E	SW	7.6	3.0	(6.9)	(7.5)	5.30	295	0	248	290	135	0.0034	0.0057
13S/19E	S, SW	14.6	15.0	16.5	10.3	13.85	850	880	998	505	792	0.00076	0.0034
13S/20E	S, SW	8.8	10.1	9.9	8.5	9.27	390	490	475	365	425	0.0013	0.0037
13S/21E	W, SW	10.2	12.0	6.2	(7.4)	8.64	498	642	198	284	375	0.0019	0.0076
13S/22E	SW	4.9	8.9	(7.5)	(7.4)	6.88	110	397	290	283	247	0.0017	0.0034
14S/19E	W, SW	10.7	12.5	13.2	8.3	11.01	538	682	740	348	565	0.0011	0.003
14S/20E	W	9.8	10.5	8.9	9.0	9.35	467	525	395	405	432	0.0001	0.0021
14S/21E	W	10.3	11.7	11.0	15.1	14.21	505	620	565	890	820	0.0031	0.0042
14S/22E	W, SW, S	14.2	15.1	10.8	9.2	11.54	820	890	545	420	610	0.0011	0.0021
15S/19E	SW	12.3	12.5	14.4	11.4	12.75	665	682	835	595	700	0.0011	0.0027
15S/20E	W, SW	14.3	14.3	13.9	13.5	13.89	828	828	797	765	795	0.0011	0.0027
15S/21E	W, SW	14.8	16.1	13.0	8.6	12.35	865	965	720	370	670	0.00095	0.0021
15S/22E	S, SW	15.8	14.2	14.1	9.9	12.98	942	820	821	475	720	0.00076	0.0038

1/ Mount Diablo Base and Meridian
2/ Numbers enclosed by parentheses indicate values estimated from adjacent or similar areas

previously mentioned. The Fresno Irrigation District estimates that approximately 50 percent of the water conveyed by its canals is lost by seepage before delivery. At the end of the irrigation season the canal system and ponding sites of the Fresno Irrigation District are sometimes used as recharge facilities. Numerous other small recharge facilities are located throughout the area and are operated by other agencies.

Ground Water Quality

Factors which may influence the quality of ground water in the area are:

1. The amount and quality of natural recharge derived from the intermittent streams to the northeast and east.
2. The amount and quality of Kings and San Joaquin River waters recharged through these same stream channels, and through unlined canals, ditches, and ponding sites.
3. The amount and quality of recharge obtained from the deep percolation of irrigation waters in the surrounding area.
4. The amount and quality of recharge from suburban areas without sewer systems.
5. The amount and quality of recharge in the Fresno area where heaviest municipal pumping occurs.
6. Water well and leach well construction practices.

In general, the ground water quality in the metropolitan area is very good. Table 3 presents the maximum, minimum, mean, and median concentration values of the constituents in the ground water samples tabulated in Table D-2, Appendix D. Generally, higher values were obtained from the area surrounding the Fresno Sewage Treatment Plant and

TABLE 3
SUMMARY OF GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Mineral Constituents in Parts Per Million (ppm)	Maximum	Mean	Median	Minimum
pH	9.2	7.8	7.8	7.3
Calcium (Ca)	108	27	20	2.4
Magnesium (Mg)	53	13	11	0.0
Sodium (Na)	112	21	16	5.6
Potassium (K)	13	4.7	4.3	1.5
Sulfate (SO_4)	22	9.4	7.2	0.0
Chloride (Cl)	94	20.6	12.0	1.9
Fluoride (F)	0.4	0.13	0.1	0.0
Nitrate (NO_3)	58.5	15.1	13.0	0.8
Boron (B)	0.34	0.1	0.07	0.00
Silica (SiO_2)	102	64	67	23
Alkalinity (HCO_3)	585	144	110	39
Dissolved Solids	708	268	220	86
Total Hardness as $CaCO_3$	384	127	100	44
Alkyl Benzene Sulfonate (ABS)	0.3	<0.1	0.0	0.0

from three wells located in the vicinity of the Pacific Fruit Express ice plant and the abandoned Southern Pacific zeolite water softening plant.

Extremely high mineral concentrations in the vicinity of the ice plant and water softening plant prompted an investigation in 1953 by the Division of Water Resources of the State Department of Public Works (5). Corrective measures taken at the conclusion of that investigation have improved the ground water quality; however, the water is still of a lower quality than that of the surrounding area.

Plate 8 is a plot of three ranges of total hardness concentration. The plate indicates an apparent belt of higher total hardness values. The belt lies for the most part in the southeastern portion of the metropolitan area. Other high values appear in the area surrounding the Fresno Sewage Treatment Plant and the three wells located in the vicinity of the previously mentioned ice plant and abandoned zeolite water softening plant.

Ranges of dissolved-solids concentrations for the area are shown on Plate 9. Although no particular correlation exists, dissolved-solids concentrations appear in a pattern similar to total hardness.

Nitrate concentrations in ground water in the central portion of the San Joaquin Valley average approximately 11 ppm, whereas the average in the area of investigation is 15 ppm. Plate 10 shows three ranges of nitrate concentrations for the area. It will be noted that high nitrate concentrations exist in the area southwest of the Fresno Air Terminal and in the vicinity of the Fresno Sewage Treatment Plant. The area southwest of the air terminal lies outside the Fresno city limits and is an unsewered region. Many wells located in these areas have nitrate concentrations near or above the drinking water standards of 45 ppm described in Appendix B, Water Quality Criteria. Most of the higher concentrations were found in shallower wells (Plate 11).

ABS was found only in ground water in the immediate vicinity of the Fresno Sewage Treatment Plant. In this area four wells contained concentrations ranging from 0.1 to 0.3 ppm.

Ground water temperatures were measured during the spring, summer, and fall to detect any abnormal changes. Ground water is used by a number of individuals and firms as cooling water for refrigeration and air-conditioning systems and then returned to the ground water through injection wells. In the past, some isolated regions of high ground water temperature conditions occurred during the months air-conditioners were in use. The problem appeared most acute in the cases where the return was discharged near the same depth from which it was pumped. These high-temperature regions have evidently been corrected, since ground water temperature measurements made over the season ranged from 65 to 78°F. Temperatures above 80°F. are considered a problem.

CHAPTER III. WASTE DISPOSAL

The major waste disposal facilities in the metropolitan area are indicated on Plate 7. A list of these in Table 4 shows the quantity discharged and the methods of treatment and disposal. A major waste discharge not listed is the individual septic tank and leach well combinations used in areas not served by public disposal systems. The total volume of waste discharged by individual disposal systems is not known but is estimated to be approximately three million gallons per day. By city ordinance all new structures constructed within the City of Fresno and any area annexed to the city must be connected to the city sewerage system. Central sewerage systems are also provided in the communities of Clovis, Pinedale, Malaga, and two small county sanitation districts. In the remaining metropolitan area individual septic tanks and leach wells are utilized for disposal of waste. Analyses of waste water samples are tabulated in Table D-3, Appendix D.

High nitrate concentrations found in shallow ground water in the region southwest of the Fresno Air Terminal are attributed to use of individual waste systems.

The City of Fresno has 276 storm inlets into the sanitary sewer and 430 storm inlets into the storm drainage system. The waste water from the storm drainage system is percolated into the ground at ponding sites provided by the Fresno Municipal Flood Control District and in over 900 disposal wells maintained by the city.

TABLE 4
MAJOR WASTE DISPOSAL FACILITIES
FRESNO-CLOVIS METROPOLITAN AREA

Unit	Quantity of Waste Water		Treatment Facilities	Method of Disposal
	Design Flow	Mean Flow		
Fresno City Sewage Treatment Plants	51 mgd[1/]	27 mgd	Clarifiers, digesters, vacuators, and trickling filters	Percolation and evaporation by ponding; irrigation
Clovis City Sewage Treatment Plant	1.3 mgd	0.7 mgd	Clarifiers, digesters, and trickling filters	Percolation and evaporation by ponding
Pinedale Public Utility Commission	-	0.02 mgd	Clarifier, digester, and holding tank	Percolation and evaporation by ponding
Pinedale Sewage Treatment Plant	0.8 mgd	-	Clarifier, digester, and aeration basin	Percolation and evaporation by ponding
Fresno County Sanitation District I	0.25 mgd	0.167 mgd	Package plant aeration unit	Percolation and evaporation by ponding
Fresno County Sanitation District II	0.02 mgd	-	Package plant aeration unit	Percolation and evaporation by ponding
Malaga Sewage Treatment Plant	0.300 mgd	0.136 mgd	Rated aeration unit	Percolation and evaporation by ponding

(Continued)

TABLE 4 (Continued)
MAJOR WASTE DISPOSAL FACILITIES
FRESNO-CLOVIS METROPOLITAN AREA

Unit	Quantity of Waste Water		Treatment Facilities	Method of Disposal
	Design Flow	Mean Flow		
Italian Swiss Colony Winery	-	0.45 mgd 2/	None	Percolation and evaporation on cultivated land; clear waste water to irrigation canal
Alta Vineyards	-	0.10 mgd 2/	Odor inhibitor added	Percolation and evaporation on cultivated land; clear waste water to irrigation canal
E & J Gallo Winery	-	1.2 mgd 2/	-	Flood irrigation; clear waste water to irrigation canal
Fresno Meat Packing Company	-	0.01 mgd	-	Percolation and evaporation by ponding

1/ Million gallons per day.

2/ Discharge during grape crushing season, approximately September 1 to November 15.

CHAPTER IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Presented below are conclusions derived from the findings and results of this investigation.

1. In general the quality of ground and surface water in the Fresno-Clovis Metropolitan Area is excellent at the present time.
2. Effluents from waste disposal systems in the metropolitan area are discharged on or under the land surface for the purpose of percolation, evaporation, and utilization by crops.
3. High ground-water temperature conditions previously noted within the area of investigation were not detected during this study.
4. In northwest Fresno near U. S. Highway 99 and West Shields the ground water quality has undergone steady upgrading since 1953. At that time the Southern Pacific zeolite water softening plant, believed to be the major source of high minerals, curtailed its operations and the Pacific Fruit Express ice plant changed its cooling process.
5. Lower quality ground water was found in the vicinity of the Fresno Sewage Treatment Plant.
6. With the exception of four wells located in the vicinity of the Fresno Sewage Treatment Plant, no evidence of ABS was found in ground waters underlying the metropolitan area.
7. Nitrate concentrations near and above the United States Public Health Service's maximum established limit of 45 ppm were found in certain locations throughout the metropolitan area. Of particular note were the high nitrates found in waters from shallow wells located in an unsewered region southwest of the Fresno Air Terminal.

8. The ground water gradient is generally from northeast to southwest.

9. A steady annual lowering of the ground water table under the heart of Fresno's downtown area together with ground water recharge due to land disposal of large quantities of effluent from the Fresno Sewage Treatment Plant have created an almost level water table in the vicinity of the plant. If these same trends continue, a reversal of ground water flow may occur, and ground water could flow from the vicinity of the sewage treatment plant toward the heart of Fresno.

Recommendations

As a result of the foregoing investigation, the department recommends that the following preventive and remedial measures be taken for the protection of the area's water supplies.

1. Water supply agencies in the Fresno-Clovis Metropolitan Area should utilize sound water conservation practices to ensure that the ground water gradient remains in the southwesterly direction. Methods used may include expansion of existing artificial recharge programs, control of ground water extraction, and development of supplemental surface water supplies.

2. Existing sanitary districts and disposal facilities should be expande to include all present and future residential and industrial developments within the more populated portions of the metropolitan area. Ultimately all individual systems in these more populated portions utilizing septic tanks and leach wells should be eliminated.

3. Standards for the construction and abandonment of water wells should be established and enforced through county ordinance. Standards shou include requirements for protection of wells from organic and mineral contamination and establish requirements for drilling wells in aquife of objectionable water quality conditions.

4. All future and existing water wells in the Fresno-Clovis Metropolitan Area should be registered with a duly authorized agency. Registration should include a listing of all available information on the physical characteristics of the well and attached pumping equipment.

5. Monitoring programs by local agencies should include the continuation of ground water level measurements, and the physical and mineral analyses of ground and surface water should be expanded to ensure an adequate coverage of the area. Frequent monitoring should be conducted in areas of apparent or potential degradation.

APPENDIX A

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APPENDIX A

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APPENDIX B

WATER QUALITY CRITERIA

APPENDIX B

WATER QUALITY CRITERIA

Criteria presented in the following sections can be utilized in evaluating mineral quality of water relative to existing or anticipated beneficial uses. It should be noted that these criteria are merely guides to the appraisal of water quality. Except for those constituents, which are considered toxic to human beings, these criteria should be considered as suggested limiting values. A water which exceeds one or more of these limiting values need not be eliminated from consideration as a source of supply, but other sources of better quality water should be investigated.

Domestic and Municipal Water Supply

The following tabulation gives the limiting concentrations of mineral constituents for drinking water, as prescribed by the United States Public Health Service.

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1962

Constituent	Mandatory limit in ppm
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Hexavalent chromium (Cr^{+6})	0.05
Cyanide	0.2
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

Constituent	Nonmandatory, but recommended limit
Alkyl benzene sulphonate (detergent)	0.5
Arsenic (As)	0.01
Carbon chloroform extract (exotic organic chemicals)	0.2
Chloride (Cl)	250
Copper (Cu)	1.0

UNITED STATES PUBLIC HEALTH SERVICE
DRINKING WATER STANDARDS
1962 (continued)

Constituent	Nonmandatory, but recommended limit
Cyanide	0.01
Fluoride (F)	1.7
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (NO_3)	45
Phenols	0.001
Sulfate (SO_4)	250
Total dissolved solids	500
Zinc (Zn)	5

In addition, the United States Public Health Service recently announced limits on concentrations of radioactivity in drinking waters. These limits are as follows:

Radionuclide	Recommended maximum limits micromicrocuries per liter
$Radium^{226}$	3
$Strontium^{90}$	10
Gross beta activity	1,000*

Interim standards for certain mineral constituents have recently been adopted by the California State Board of Public Health. Based on these standards, temporary permits may be issued for drinking water supplies failing to meet the United States Public Health Service Drinking Water Standards, provided the mineral constituents in the following table are not exceeded.

UPPER LIMITS OF TOTAL SOLIDS AND SELECTED MINERALS IN DRINKING WATER AS DELIVERED TO THE CONSUMER

	Permit	Temporary Permit
Total solids	500 (1000)**	1500 ppm
Sulfates (SO_4)	250 (500)**	600 ppm
Chlorides (Cl)	250 (500)**	600 ppm
Magnesium (Mg)	125 (125)	150 ppm

* In the known absence of strontium -90 and alpha emitters.
**Numbers in parentheses are maximum permissible, to be used only where no other more suitable waters are available in sufficient quantity for use in the system.

The California State Board of Public Health has defined the maximum safe amounts of fluoride ion in drinking water in relation to mean annual temperature.

Mean annual temperature	Mean monthly fluoride ion concentration
50°F	1.5 ppm
60°F	1.0 ppm
70°F - above	0.7 ppm

Even though hardness of water is not included in the above standards, it is of importance in domestic and industrial uses. Excessive hardness in water used for domestic purposes causes increased consumption of soap and formation of scale in pipe and fixtures. The following tabulation for degrees of hardness has been suggested by the Department of Water Resources:

Range of hardness, expressed as $CaCO_3$, in ppm	Relative classification
0 - 100	Soft
100 - 200	Moderately hard
200 & greater	Hard

Industrial Water Supply

Water quality criteria for industrial waters are as varied and diversified as industry itself. Food processing, beverage production, pulp and paper manufacturing, and textile industries have exacting requirements. However, cooling or metallurgical operations permit the use of poor quality waters. In general, where a water supply meets drinking water standards, it is satisfactory for industrial use, either directly or following a limited amount of polishing treatment by the industry.

Irrigation Water

Criteria for mineral quality of irrigation water have been developed by the Regional Salinity Laboratories of the United States Department

of Agriculture in cooperation with the University of California. Because of diverse climatological conditions and the variation in crops and soils in California, only general limits of quality for irrigation waters can be suggested.

QUALITATIVE CLASSIFICATION OF IRRIGATION WATERS

Chemical properties	Class 1, excellent to good	Class 2, good to injurious	Class 3, injurious to unsatisfactory
Total dissolved solids, in ppm	Less than 700	700 - 2000	More than 2000
Conductance, in micromhos at 25°C	Less than 1000	1000 - 3000	More than 3000
Chlorides in ppm	Less than 175	175 - 350	More than 350
Sodium in percent of base constituents	Less than 60	60 - 75	More than 75
Boron in ppm	Less than 0.5	0.5 - 2.0	More than 2.0

These criteria have limitations in actual practice. In many instances a water may be wholly unsuitable for irrigation under certain conditions of use, and yet be completely satisfactory under other circumstances. Consideration also should be given to soil permeability, drainage temperature, humidity, rainfall, and other conditions that can alter the response of a crop to a particular quality of water.

Classification of Waters

Waters are generally classified according to their quality, character or type. The quality of a water is determined by the kind and quantity of dissolved constituents, expressed as parts per million (ppm), or by a related characteristic such as electrical conductivity, measured in micromhos per centimeter.

The character or type of a water is determined by the relative proportions of mineral constituents. Most dissolved constituents in water are dissociated into charged ions, both cations (positive charge) and anions (negative charge). Substances determined in this study by mineral water analyses and expressed as ions include cations: calcium, magnesium, sodium and potassium; and anions: carbonate, bicarbonate, sulfate, fluoride, chloride and nitrate.

Classified Name for Waters

The classified name for waters, with respect to mineral composition, is in terms of the predominant ions. Specifically, the name of an ion is used where it constitutes at least half of its ionic group, expressed in equivalent weights. Where no one ion fulfills the requirement, a hyphenated combination of the two most abundant constituents is used. Thus a calcium bicarbonate water denotes that calcium constitutes at least half of the cations and bicarbonate represents at least half of the anions. Where calcium, though predominant, is less than half, and sodium next in abundance, the name is modified to calcium-sodium bicarbonate.

APPENDIX C

LOCATION DESIGNATION SYSTEM

APPENDIX C

LOCATION DESIGNATION SYSTEM

The system used in this investigation to designate the location of wells and other points is based upon the township, range and section subdivisions of the Federal Land Survey. This system divides each section (square mile) into 40-acre tracts which are lettered as follows:

D	C	B	A
E	F	G	H
M	L	K	J
N	P	Q	R

The letters "I" and "O" have not been utilized in the system because of the possibility of confusing them with numerals.

Wells contained within the boundaries of each of these 40-acre tracts are numbered according to the chronological order in which they were located. For example, a well designated as 13S/20E - 25 E2 is the number of a well in Section 25 of Township 13 South, Range 20 East. The E2 indicates that this is the second well to be located in the 40-acre tract. The land subdivision referred to in this area is the Mount Diablo Base and Meridian.

APPENDIX D

BASIC DATA

APPENDIX D

BASIC DATA

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TABLE D-1
SURFACE WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Location Number	Date Sampled Month and Year	pH	Mineral Constituents-Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
Dry Creek																
11S/23E-30P	5-63	7.8	20	14	16	2.4	4.6	8.7	0.1	1.8	0.08	42	151	177	108	-
12S/22E-20P	5-63	-	-	-	-	-	-	12[a]	-	0.3	-	-	-	-	121[a]	0.0
14S/19E-23E	6-63	7.2	4.9	0.2	2.8	1.0	0.2	1.0	0.2	0.3	0.06	12	18	36	13	0.0
14S/19E-30D	6-63	7.1	5.3	0.0	2.7	1.0	3.4	1.5	0.2	0.5	0.08	10	18	48	13	0.0
Fancher Creek																
12S/23E-21B	5-63	8.1	80	56	28	5.8	341	21	0.2	1.9	0.12	54	130	671	430	-
	11-63	7.6[a]	-	-	-	-	8[a]	-	-	-	-	-	-	-	270[a]	-
Gould Canal																
13S/21E-16N	5-63	-	-	-	-	-	-	6[a]	-	-	-	-	-	-	89[a]	-
13S/21E-17N	5-63	-	-	-	-	-	-	4[a]	-	-	-	-	-	-	16[a]	-

a - Laboratory Field Kit

(Continued)

SURFACE WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Location Number	Date Sampled Month and Year	pH	Mineral Constituents-Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
Kings River below Pine Flat Dam																
13S/24E-2A	5-63	6.9	4.8	0.7	2.0	1.1	2.4	1.1	0.0	0.6	0.0	7.7	1.8	44	15	-
San Joaquin River below Friant Dam																
11S/21E-7P	5-63	6.7	4.2	1.3	4.5	-	1.0	3.8	0.1	2.2	0.1	10	22	45	16	-

TABLE D-2
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
12S/20E-32J1	4-51	7.4	17	7.7	14	-	3.1	5.0	0	11	-	-	87	163	75	-
	7-58	7.8	19	7.9	15	3.6	1.8	7.7	0.2	14	0.00	58	111	181	80	-
	7-60	7.8	19	8.4	14	3.4	2.3	7.9	0.2	15	0.08	64	108	187	82	-
	6-62	7.9	19	7.7	15	4.1	2.3	9.1	0.2	12	0.07	63	108	185	79	-
	5-63	7.9	21	7.7	15	3.3	2.6	6.9	0.3	6.9	0.25	61	134	208	84	-
-33M2	4-51	7.6	18	8.1	14	-	0	10	0	1.8	-	-	92	165	78	-
	6-63	-	-	-	-	-	-	13[a]	-	6.8	-	-	-	188[b]	77[a]	0.0
-33K	3-56	8.2	17	7.1	14	3.6	5.5	5	0.1	5.3	-	-	91	169	72	-
	6-63		-	-	-	-	-	12[a]	-	14	-	-	-	194[b]	77[a]	0.0
13S/19E-24Q1	5-53	7.2	102	45	418	12	26	840	0.1	37	0.03	64	160	1,590	440	-
	7-54	8.2	99	24	369	13	24	720	0.0	33	0.00	71	155	1,400	345	-
	6-63	7.2	60	26	88	7.5	9.5	225	0.3	43	0.25	82	116	693	161	-
-25B4	6-63	-	-	-	-	-	-	257[a]	-	11	-	-	-	814[b]	182[a]	0.0
-25C3	6-63	-	-	-	-	-	-	240[a]	-	-	-	-	-	779[b]	222[a]	-
-28B	6-63	-	-	-	-	-	-	10[a]	-	14	-	-	-	182[b]	69[a]	0.0
-29E1	7-63	7.7	30	8.5	18	4.9	6.1	13	0.2	13	0.06	102	141	237	110	-
-32D1	6-63	7.4	26	14	21	5.4	8.7	15	0.2	17	0.07	73	157	262	125	-
-36E2	5-63	8.0	16	7.5	14	4.8	3.1	3.9	0.2	10	0.05	73	108	180	71	0.0
13S/20E-3C1	7-60	8.0	19	7.9	11	2.8	2.3	6.2	0.2	6.7	0.11	63	109	173	80	-
	5-61	7.6	18	9	12	3	2	6	0.1	11	-	-	89	159	82	-
	6-63	-	-	-	-	-	-	12[a]	-	10	-	-	-	182[b]	77[a]	0.0

FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/20E-4P	6-63	-	-	-	-	-	-	10[a]	-	13	-	-	-	205[b]	93[a]	0.0
-5R	6-63	-	-	-	-	-	-	12[a]	-	14	-	-	-	229[b]	105[a]	0.0
-6F1	6-63	8.0	21	5.0	15	3.2	3.3	7.2	0.4	7.1	0.28	56	104	199	73	0.0
-7F1	6-63	-	-	-	-	-	-	13[a]	-	17	-	-	-	188[b]	77[a]	0.0
-7L1	6-63	-	-	-	-	-		10[a]	-	8.4	-	-	-	199[b]	81[a]	0.0
-8E1	10-59	7.7	18	8.8	15	3.5	4.9	7.0	0.05	6.6	-	-	97	188	81	-
	6-63	-	-	-	-	-	-	10[a]	-	7.8	-	-	-	217[b]	101[a]	0.0
-8P1	8-58	8.2	14	6.6	10	2.8	3.5	5.5	0.1	7.1	-	77.5	-	144	63	-
	6-63	-	-	-	-	-	-	10[a]	-	8.0	-	-	-	176[b]	73[a]	0.0
-9F2	3-60	8.0	16	10	12	3.4	3.6	6.8	0.1	11	-	-	84	215	78	-
	5-63	-	-	-	-	-	-	10[a]	-	12	-	-	-	176[b]	75[a]	0.0
-9M1	8-58	8.1	16	8.2	11	3.0	4.1	5.5	0.1	8.9	-	-	86	162	75	-
	6-63	-	-	-	-	-	-	8[a]	-	10	-	-	-	176[b]	77[a]	0.0
-9Q1	5-63	8.1	19	10	13	3.2	3.8	5.3	0.2	10	0.06	69	118	182	87	0.0
-10K1	2-53	-	20	7.0	13	-	0.0	1.4	0.0	4.4	-	-	62	146	79	-
	6-63	-	-	-	-	-	-	12[a]	-	16	-	-	-	199[b]	81[a]	0.0
-10Q1	11-61	7.6	6.6	6.9	11	3.1	3.5	3.1	0.2	7.5	-	-	55	136	45	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	176[b]	75[a]	-
-11G1	5-61	8.1	15	10	12	2.4	2.4	4.8	0.1	12	-	-	92	175	77	-
	5-63	-	-	-	-	-		10[a]	-	-	-	-	-	182[b]	81[a]	-

(Continued)

TABLE D-2(Continued)
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/20E-12L1	7-58	7.5	16	10	11	2.1	1.6	4.4	0.2	6.8	0.00	54	110	160	79	-
	7-60	7.9	18	10	10	2.4	4.4	3.7	0.1	6.4	0.06	60	115	171	86	-
	4-62	8.2	24	12	14	2	0	8	0.47	0	0.06	-	160	200	111	0.0
	6-63	7.8	14	5.4	9.2	1.5	5.1	3.8	0.2	0.8	0.02	23	-	86	57	-
-13H1	11-62	7.6	18	8.4	16	2.9	5.1	6.5	0.1	12	-	-	100	190	80	-
	5-63		-	-	-	-	-	10[a]	-	-	-	-	-	188[b]	80[a]	-
-14M1	10-60	7.6	13	8.8	12	4.0	4.9	3.4	0.01	8.4	-	-	79	162	69	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	164[b]	67[a]	-
-16L1	8-57	8.1	16	8.2	11	3.8	2.7	5.8	0.2	13	-	-	81	160	73	-
	6-63	-	-	-	-	-	-	13[a]	-	18	-	-	-	194[b]	85[a]	0.0
-16R1	11-56	7.7	11	5.9	10	3.4	3.8	3.0	0.1	5.3	-	-	58	113	52	-
	5-63		-	-	-	-	-	8[a]	-	11	-	-	-	164[b]	65[a]	0.0
-17A1	4-62	7.9	16	8.6	12	3.9	4.5	4.5	0.1	6.2	-	-	86	182	75	-
	6-63	-	-	-	-	-	-	10[a]	-	10	-	-	-	182[b]	77[a]	0.0
-17E1	6-63	-	-	-	-	-	-	10[a]	-	8.6	-	-	-	182[b]	77[a]	0.0
-17F1	11-61	7.6	14	11	12	2.9	1.6	5.5	0.2	8.0	-	-	89	170	80	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	170[b]	71[a]	-
-17R1	2-61	7.9	15	8	12	4	3	6	0.1	12	-	-	77	166	70	-
	6-63	-	-	-	-	-	-	12[a]	-	15	-	-	-	188[b]	73[a]	0.0
-19C1	8-57	7.8	15	8.7	13	3.0	4.9	4.8	0.1	10	-	-	83	158	75	-
	6-63	-	-	-	-	-	-	6[a]	-	-	-	-	-	176[b]	77[a]	-

FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/20E-20H1	12-56	7.5	17	7.9	15	4.0	10	9.1	0.00	12	-	-	78	171	76	-
	5-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	182[b]	80[a]	-
-20N1	8-57	7.7	14	6.4	11	3.2	6.1	5.0	0.2	11	-	-	66	134	62	-
	6-63	7.7	16	7.3	11	3.9	3.3	5.4	0.1	10	0.06	68	93	168	70	-
-20R1	8-57	7.7	14	7.8	11	3.5	6.5	5.0	0.1	14	-	-	75	172	68	-
	6-63	-	-	-	-	-	-	8.0[a]	-	-	-	-	-	182[b]	77[a]	-
-21E1	8-57	7.6	14	7.2	11	4.7	4.3	6.5	0.1	16	-	-	70	146	66	-
	6-63	-	-	-	-	-	-	13[a]	-	18	-	-	-	182[b]	69[a]	0.0
-21F1	10-51	7.7	12	7.1	9.5	3.1	3.7	3.8	0	5.4	0.60	69	83	162	59	-
	5-52	7.7	14	5.1	9.0	3.9	4.4	3.2	0	5.0	0.01	68	-	152	56	-
	5-63	-	-	-	-	-	-	10[a]	-	10	-	-	-	158	65[a]	-
-21J1	8-57	7.7	9.1	5.4	10	3.3	4.6	2.5	0.14	4.9	-	-	59	108	45	-
	11-62	7.5	10	6.4	10	3.4	4.3	3.0	0.1	4.4	-	-	60	153	52	-
	5-63	-	-	-	-	-	-	8[a]	-	-	-	-	-	135[b]	44[a]	-
-22L1	8-59	7.7	8.5	5.6	10	3.3	3.7	2.0	0.1	4.4	-	-	57	140	44	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	129[b]	46[a]	-
-23B1	12-56	8.0	14	10	15	3.3	6.8	5.8	0.00	12	-	-	71	153	73	-
	6-63	-	-	-	-	-	-	6[a]	-	-	-	-	-	170[b]	73[a]	-
-23J1	10-60	7.6	15	10	15	3.6	7.0	6.0	0.1	17	-	-	85	175	81	-
	5-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	182[b]	71[a]	-
-24R1	8-58	8.2	16	8.5	17	3.8	8.7	5.0	0.1	16	-	-	89	183	76	-
	6-63		-	-	-	-	-	8[a]	-	16	-	-	-	153[b]	49[a]	0.0

(Continued)

TABLE D-2 (Continued)
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/20E-25E2	5-63	-	-	-	-	-	-	12[a]	-	45	-	-	-	293[b]	125[a]	0.0
-25G	5-63	-	-	-	-	-	-	13[a]	-	16	-	-	-	235[b]	97[a]	0.0
-26C1	3-51	7.7	14	10	18	-	0.0	4.3	0.1	11	-	67	71	210	74	-
	4-62	8.3	19	12	23	5.8	18	6.0	0.1	22	-	-	106	235	95	-
	6-63	-	-	-	-	-	-	12[a]	-	28	-	-	-	270[b]	113[a]	0.0
-26D1	11-61	7.6	16	13	11	2.0	3.0	6.2	0.15	14	-	-	91	184	92	-
	5-63	-	-	-	-	-	-	6[a]	-	-	-	-	-	129[b]	38[a]	-
-26L1	3-51	7.8	19	11	18	-	9.0	6.5	0.0	13	-	-	102	202	92	-
	4-62	7.8	26	15	24	5.9	18	10	0.1	30	-	-	130	278	128	-
	6-63	-	-	-	-	-	-	12[a]	-	30	-	-	-	275[b]	121[a]	0.0
-27F1	5-52	7.8	11	6.3	11	3.4	5.4	2.4	0	6.1	0.02	69	82	155	53	-
	5-55	7.7	13	6.8	12	3.1	6.2	2.0	0	5.3	-	-	71	135	61	-
	4-59	7.4	8.9	6.3	10	2.9	5.6	3.4	0.2	6.7	0.15	41	72	120	48	-
	7-63	-	-	-	-	-	-	6[a]	-	-	-	-	-	147[b]	49[a]	-
-27G1	12-49	7.8	11	7.1	21	-	19	7.1	-	-	56	95	-	210	57	-
	10-51	8.0	12	7.4	13	3.1	6.3	4.2	0	7.6	0	69	90	167	60	-
	7-63	7.6	22	0.0	13	3.4	7.9	2.9	0.3	9.4	0.09	67	78	164	55	-
-27J1	5-55	7.7	13	7.1	14	3.8	7.8	3.6	0.1	7.1	-	-	82	156	62	-
	7-58	7.9	14	8.3	14	3.8	4.6	4.2	0.2	10	0.00	65	104	175	69	-
	7-60	7.9	16	9.0	13	4.0	5.8	4.0	0.2	10	0.06	66	107	181	77	-
	10-61	8.2	14	10	15	4.0	5.6	5.8	0.1	10	0.0	65	106	181	75	-
	6-62	-	-	-	15	4.1	-	4.8	-	-	0.07	-	-	-	75	0.0
	6-63	7.8	18	8.5	15	4.2	7.1	4.5	0.1	14	0.16	65	108	182	80	-

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/20E-28C1	5-52	7.7	14	6.6	10	3.6	4.9	3.6	0	5.2	0	63	92	156	62	-
	8-57	7.8	13	8.7	12	4.4	6.2	4.8	0	11	-	-	73	145	68	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	188[b]	88[a]	-
-28R1	7-63	-	-	-	-	-	-	8[a]	-	-	-	-	-	164[b]	61[a]	-
-29K1	8-57	8.0	13	8.1	12	4.3	6.0	5.3	0.1	15	-	-	74	149	67	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	182[b]	73[a]	-
-30M1	6-63	-	-	-	-	-	-	13[a]	-	15	-	-	-	205[b]	85[a]	0.0
-30M2	6-63	-	-	-	-	-	-	17[a]	-	19	-	-	-	217[b]	89[a]	0.0
-32D1	10-60	7.6	14	9.0	15	5.7	5.2	7.2	0.03	18	-	-	77	188	71	-
	6-63	7.7	16	8.5	14	5.5	4.0	6.9	0.2	16	0.04		86	198	75	-
-32L2	8-57	7.8	19	12	19	5.8	11	9.3	0.0	90	-	-	99	211	99	-
	5-63	-	-	-	-	-	-	15[a]	-	-	-	-	-	235[b]	109[a]	-
	11-63	-	-	-	-	-	-	-	-	12.6	-	-	-	-	-	-
-33D1	5-52	7.7	20	14	17	5.6	9.5	8.2	0	11	0	74	147	232	107	-
	8-57	7.9	21	13	19	5.6	8.6	8.5	0.1	17	-	-	117	230	109	-
	4-59	7.8	23	13	19	5.4	10	7.7	0.1	11	0.08	-	153	236	111	-
	5-63	-	-	-	-	-	-	13[a]	-	-	-	-	-	240[b]	113[a]	-
-33P1	5-52	7.7	32	8.3	16	5.5	9.3	7.8	0	9.5	0	73	152	236	114	-
	8-57	8.2	23	13	18	5.4	7.2	9.5	0.0	16	-	-	119	232	114	-
	4-59	7.8	30	18	18	5.4	13	10	0.1	11	0.08	73	185	270	147	-
	5-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	223[b]	105[a]	-

(Continued)

TABLE D-2(Continued)
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/20E-34B1	5-55	7.7	18	11	18	5.2	11	7.1	0.08	15	-	-	102	209	91	-
	5-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	199[b]	81[a]	-
-34H1	5-55	7.9	17	7.9	16	4.7	11	6.4	0.1	11	-	-	90	183	75	-
	5-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	188[b]	77[a]	-
-34M1	8-51	8.8	30	19	23	6.0	10	14	0	21	0	75	174	297	153	-
	4-59	7.6	20	10	18	4.7	6.6	8.1	0.3	22	0.18	31	123	182	91	-
	5-63	7.7	19	9.1	18	4.8	5.8	6.8	0.2	12	0.05	68	122	192	85	-
-35D1	5-51	7.7	16	4.4	12	3.4	6.0	3.6	0.1	5.2	0	70	89	164	58	-
	5-55	7.9	14	6.2	14	4.0	10	4.0	0.1	8.0	-	-	77	154	61	-
	4-59	7.4	16	7.8	13	3.6	8.9	5.6	0.2	6.1	0.22	36	98	145	72	-
	5-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	211[b]	93[a]	-
-35H2	11-62	7.6	17	10	19	5	10	7.0	0.1	20	-	-	90	213	82	-
	5-63	-	-	-	-	-	-	13[a]	-	16	-	-	-	194[b]	81[a]	0.0
-36D1	10-54	7.4	5.9	3.3	5.6	2.0	2.4	0.8	0.0	0.9	-	-	39	67	28	-
	6-63	-	-	-	-	-	-	8[a]	-	9.2	-	-	-	147[b]	56[a]	0.0
-36K1	7-63	-	-	-	-	-	-	15[a]	-	47	-	-	-	357[b]	178[a]	0.0
13S/21E-4P1	6-50	7.4	22	12	19	-	2.8	10	0.00	8.8	-	-	120	192	104	-
	4-62	8.1	20	14	16	2.6	3.0	11	0.25	15	-	-	116	202	106	-
	5-63	7.6	21	12	17	2.2	4.1	8.7	0.2	8.4	0.07	58	142	198	102	-
-7G2	5-63	-	-	-	-	-	-	19[a]	-	43	-	-	-	299[b]	159[a]	0.0
-8E	5-63	-	-	-	-	-	-	13[a]	-	-	-	-	-	199[b]	101[a]	-
	11-63	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/21E-8J1	3-59	7.8	23	14	18	3.0	3.2	10	0.1	19	-	-	144	234	116	-
	5-63	-	-	-	-	-	-	17[a]	-	-	-	-	-	252[b]	125[a]	-
	11-63	-	-	-	-	-	-	-	-	10.1	-	-	-	-	-	-
-15N2	7-58	7.8	9.3	6.1	13	1.6	3.1	2.8	0.3	5.5	0.00	44	81	126	48	-
	7-60	7.8	10	6.8	13	1.8	5.4	2.8	0.2	5.1	0.08	44	84	130	53	-
	4-62	8.1	9	7	16	2	7	7	0.25	4	0.02	29	81	150	50	0.0
	6-63	7.9	8.3	6.0	12	1.5	4.4	1.9	0.2	3.7	0.04	45	76	114	45	-
-16N	6-63	-	-	-	-	-	-	10[a]	-	14	-	-	-	176[b]	65[a]	0.0
-17F1	5-63	7.9	17	10	16	3.4	12	6.8	0.2	11	0.03	62	106	177	85	0.0
-17J1	10-59	7.9	11	8.3	16	2	7.3	4.7	0.15	8.9	-	-	73	158	62	-
	6-63		-	-	-	-	-	8[a]	-	-	-	-	-	199[b]	81[a]	-
-17Q1	6-63		-	-	-	-	-	10[a]	-	21	-	-	-	229[b]	93[a]	0.0
-19A1	5-63	7.5	14	10	14	4.6	11	3.4	0.2	5.2	0.04	68	111	174	77	0.0
-21P	5-62	8.1	21	14	18	4.0	14	7.8	0.1	10	-	-	112	208	108	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	235[b]	109[a]	-
-29A1	6-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	346[b]	186[a]	-
-30E2	8-57	8.2	17	11	20	5.8	13	4.5	0.1	3.0	-	-	105	208	89	-
	5-63	-	-	-	-	-	-	12[a]	-	31	-	-	-	229[b]	85[a]	0.0
-31E2	11-61	7.6	6.6	6.9	11	3.1	3.5	3.1	0.2	7.5	-	-	55	136	45	-
	5-62	8.0	26	17	23	4.3	12	13	0.05	19	-	-	140	258	134	-
	5-63	-	-	-	-	-	-	19[a]	-	21	-	-	-	264[b]	126[a]	0.0

(Continued)

TABLE D-2 (Continued)
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
13S/21E-31G1	6-63	-	-	-	-	-	-	25[a]	-	36	-	-	-	340[b]	182[a]	0.0
-31M1	6-63	8.2	47	26	31	10	38	19	0.3	39	0.15	73	245	407	224	-
-31Q	5-63	-	-	-	-	-	-	23[a]	-	16	-	-	-	398[b]	234[a]	0.0
14S/18E-25A1	6-63	8.0	38	16	29	6.0	11	33	0.3	13	0.20	64	193	293	162	-
14S/19E-4R1	7-63	8.2	32	4.6	16	5.4	5.3	15	0.2	10	0.07	77	126	227	99	-
-7M1	7-58	8.3	46	14	23	6.5	9.2	15	0.2	7.2	0.04	84	220	321	174	-
	7-60	8.4	38	18	24	6.3	6.9	16	0.1	8.4	0.07	85	230	321	171	-
	6-62	8.4	42	21	28	6.6	8.4	15	0.1	11	0.11	77	263	342	192	-
	6-63	8.0	44	21	30	6.6	8.6	13	0.1	12	0.04	74	276	318	198	-
-14C	6-63	-	-	-	-	-	-	44a	-	-	-	-	-	562[b]	279[a]	-
-14P1	10-62	7.9	13	7.8	30	2.5	20	7.1	0.1	20	0.0	34	101	182	65	-
	6-63	7.4	12	7.0	28	2.6	9.4	8.2	0.1	16	0.08	47	104	179	59	-
-15H1	6-63	-	-	-	-	-	-	19[a]	-	-	-	-	-	334[b]	156[a]	-
-15J	6-63	-	-	-	-	-	-	29[a]	-	-	-	-	-	426[b]	218[a]	-
-19F1	6-63	-	-	-	-	-	-	17[a]	-	29	-	-	-	240[b]	95[a]	0.0
-19K1	6-63	-	-	-	-	-	-	35[a]	-	30	-	-	-	375[b]	190[a]	0.0
-20H2	6-63	8.2	94	28	112	9.0	22	54	0.1	27	0.34	-	585	670	349	0.2
-20K2	6-63	7.5	108	53	55	13	18	58	0.1	0.7	0.11	70	648	677	487	0.1

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
14S/19E-20M2	6-63	7.7	24	11	22	6.6	7.6	19	0.1	15	0.07	74	134	250	106	0.0
-21A1	6-63	-	-	-	-	-	-	56[a]	-	52	-	-	-	591[b]	287[a]	0.0
-22P1	6-63	-	-	-	-	-	-	46[a]	-	10	-	-	-	708[b]	384[a]	0.3
-22R1	8-57	7.9	44	26	46	6.3	19	41	0.2	15	0.03	69	295	412	215	-
	7-58	8.1	37	26	45	6.0	16	40	0.1	12	0.5	66	266	379	201	-
	7-60	8.1	34	30	47	6.2	20	47	0.1	20	0.08	63	258	394	207	-
	7-62	8.3	21	28	47	6.5	19	41	0.1	21	0.06	73	219	356	166	0.0
	6-63	8.3	54	23	42	7.0	15	29	0.1	18	0.09	64	314	388	231	-
-25D	7-63	-	-	-	-	-	-	25[a]	-	-	-	-	-	281[b]	129[a]	-
-28P1	6-63	8.0	98	32	61	13	21	66	0.1	3.9	0.14	73	474	603	376	0.1
-29A1	6-63	8.2	74	41	68	11	14	49	0.1	0.8	0.27	-	527	565	353	-
-31A1	4-52	7.7	50	23	31	5.3	15	60	0	15	0.0	67	222	376	220	-
	6-63	7.3	78	41	41	10	8.9	94	0.2	14	0.09	68	368	590	365	-
-36A1	7-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	287[b]	141[a]	-
14S/20E-1D1	8-57	7.5	38	21	31	6.2	16	23	0.1	35	-	-	168	369	181	-
	5-63	-	-	-	-	-	-	25[a]	-	45	-	-	-	410[b]	218[a]	0.0
-1J1	5-62	8.2	19	13	16	3.2	7.1	7.5	0.25	21	-	-	101	212	101	-
	5-63							12[a]		21				205[b]	92[a]	-

(Continued)

TABLE D-2 (Continued)
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
14S/20E-2J1	8-57	7.9	30	18	24	5.2	8.2	14	0.1	29	-	-	153	308	148	-
	7-58	8.1	30	17	23	5.4	7.6	14	0.2	17	0.00	66	194	276	145	-
	7-60	8.2	33	17	24	5.6	8.2	14	0.2	18	0.04	70	202	289	153	-
	6-62	8.4	32	18	26	5.4	11	15	0.2	20	0.08	50	204	279	155	0.0
	5-63	7.6	34	17	26	5.6	11	14	0.2	18	0.08	67	205	286	154	-
-2Q	8-59	7.9	25	17	20	5.1	5.5	12	0.05	20	-	-	148	246	133	-
	5-63	-	-	-	-	-	-	17[a]	-	-	-	-	-	281[b]	146[a]	-
	11-63	-	-	-	-	-	-	-	-	9.4	-	-	-	-	-	-
-3A	12-56	7.8	23	13	20	5.2	10	12	0.1	4.0	-	-	112	225	111	-
	5-63	-	-	-	-	-	-	17[a]	-	-	-	-	-	270[b]	117[a]	-
-3C1	8-59	7.7	23	13	19	6.0	7.3	11	0.05	20	-	-	121	239	110	-
	5-63	-	-	-	-	-	-	15[a]	-	-	-	-	-	235[b]	104[a]	-
	11-63	-	-	-	-	-	-	-	-	10.3	-	-	-	-	-	-
-3M1	8-59	7.6	29	16	24	7.1	8.8	17	0.05	27	-	-	142	288	138	-
	6-63	7.9	32	14	24	6.0	8.2	17	0.2	24	0.13	77	173	260	138	-
-3P	8-57	7.6	34	20	27	6.4	10	21	0.0	28	-	-	162	338	167	-
	7-63	-	-	-	-	-	-	25[a]	-	-	-	-	-	357[b]	182[a]	-
	11-63	-	-	-	-	-	-	-	-	9.0	-	-	-	-	-	-
-5H1	8-57	7.4	21	13	17	5.2	6.4	9.0	0.1	17	-	-	-	217	105	-
	6-63	-	-	-	-	-	-	12[a]	-	-	-	-	-	229[b]	101[a]	-
-7M1	6-63	7.9	22	9.0	9.8	2.9	14	5.2	0.1	28	0.06	55	83	182	92	-
-7K	-	-	-	-	-	-	-	23[a]	-	-	-	-	-	328[b]	178[a]	-

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
14S/20E-8A1	5-47	7.8	38	20	24	4.7	15	29	0.12	5.8	0.04	68	212	340	175	-
	8-51	8.0	19	13	19	3.4	4.0	10	-	15	0	73	138	225	101	-
	4-59	7.8	33	18	21	6.8	13	18	0.2	32	0.07	76	173	303	157	-
	7-63	7.5	55	15	27	7.8	17	26	0.2	41	0.07	74	215	374	198	-
-8R	10-60	7.6	19	12	17	5.0	5.7	13	0	19	-	-	97	218	96	-
	5-63	-	-	-	-	-	-	17[a]	-	18	-	-	-	205[b]	85[a]	0.0
-9B	8-57	7.4	52	28	33	9.0	23	55	0.05	13	-	-	173	458	244	-
	7-63	-	-	-	-	-	-	50[a]	-	-	-	-	-	474[b]	246[a]	-
-9L2	10-60	7.7	26	16	20	5.8	7.5	16	0	23	-	-	123	256	129	-
	7-63	-	-	-	-	-	-	23[a]	-	-	-	-	-	311[b]	150[a]	-
	11-63	-	-	-	-	-	-	-	-	37	-	-	-	-	-	-
-10M2	5-63	7.5	26	14	23	5.2	6.6	13	0.2	15	0.05	71	162	238	122	-
-10R1	5-52	7.7	28	14	22	5.7	8.6	13	0	13	0	76	173	266	127	-
	8-57	7.9	19	13	16	4.8	3.4	6.8	0.1	15	-	-	114	213	102	-
	4-59	7.8	21	13	15	4.9	4.4	6.4	0.1	11	0.12	72	145	220	107	-
	5-63	-	-	-	-	-	-	15[a]	-	-	-	-	-	217[b]	100[a]	-
-11F1	8-51	8.6	28	16	26	4.7	10	13	0.0	16	0.01	72	176	280	136	-
	4-59	7.7	34	20	24	6.3	12	14	0.1	27	0.09	71	207	310	168	-
	5-63	7.6	32	18	24	5.6	11	13	0.2	19	0.06	66	199	264	154	-
-12B1	5-52	8.1	26	5.1	15	2.5	3.6	4.5	0	8.3	0.02	54	127	182	86	-
	8-57	7.9	18	11	15	2.4	2.8	5.0	0.1	13	-	-	99	186	90	-
	6-63							8[a]						199[b]	89[a]	-

(Continued)

TABLE D-2 (Continued)
GROUND WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
14S/20E-13K1	5-58	8.1	27	12	18	2.4	15	3.0	0.1	17	-	-	125	248	119	-
	5-63	8.1	20	10	14	2.4	10	2.4	0.2	8.2	0.06	58	123	180	93	-
-14F1	8-57	7.6	28	15	19	4.2	7.4	14	0.0	21	-	-	129	245	132	-
	5-63	-	-	-	-	-	-	10[a]	-	-	-	-	-	217[b]	105[a]	-
	11-63	-	-	-	-	-	-	-	-	8.5	-	-	-	-	-	-
-14Q1	3-51	7.9	23	15	15	-	0	13	0.0	18	-	-	118	227	121	-
	5-61	8.1	24	15	17	3.9	5.4	13	0.1	22	-	-	121	239	123	-
	5-63	-	-	-	-	-	-	17[a]	-	22	-	-	-	275[b]	149[a]	0.0
-15M1	8-51	8.2	22	12	15	4.8	3.9	8.5	0.0	9.6	0.49	77	146	225	104	-
	5-63	8.1	29	15	19	5.8	7.7	16	0.1	11	0.05	73	169	273	136	-
-16A1	8-57	7.7	21	13	17	4.6	4.6	10	0.0	20	-	-	112	222	106	-
	6-63	-	-	-	-	-	-	15[a]	-	-	-	-	-	281[b]	142[a]	-
	11-63	-	-	-	-	-	-	-	-	8.5	-	-	-	-	-	-
-19A1	7-63	7.7	81	18	27	7.3	18	48	0.2	25	0.08	74	283	437	276	-
-24D	12-61	7.8	2.4	13	17	4.8	3	10	0.2	5	-	-	116	-	-	-
	5-63	-	-	-	-	-	-	13[a]	-	15	-	-	-	240[b]	109[a]	0.0
-27C1	7-60	8.2	24	32	128	5.0	28	61	0.1	9.0	0.13	59	429	557	192	-
	10-61	8.2	60	32	92	5.0	18	89	0.0	11	0.00	57	426	574	280	-
	6-62	-	-	-	89	4.7	-	39	-	-	0.11	-	-	-	287	0.0
	6-63	8.3	67	34	55	5.6	10	25	0.2	4.5	0.15	59	454	482	306	-
-32L	7-63	-	-	-	-	-	-	27[a]	-	-	-	-	-	468[b]	226[a]	-

Well Number	Date Sampled Month and Year	pH	Mineral Constituents Parts Per Million (ppm)													
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_2)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)
14S/21E-4N	5-63	-	-	-	-	-	-	13[a]	-	5.0	-	-	-	223[b]	116[a]	0.0
-5B	5-63	-	-	-	-	-	-	13[a]	-	15.0	-	-	-	311[b]	186[a]	0.0
-6C1	6-63	8.1	21	12	18	2.4	8.7	6.0	0.3	7.4	0.18	53	142	186	102	-
-6E1	5-47	7.6	25	14	22	4.3	3.3	18	0.11	5.4	-	58	174	267	120	-
	8-51	8.9	20	12	19	4.7	6.6	10	0	11	0	71	128	228	99	-
	11-62	8.3	33	18	25	7.0	13	15	0.1	25	-	-	167	298	158	-
	5-63	-	-	-	-	-	-	17[a]	-	26	-	-	-	299[b]	149[a]	0.0
-7M	11-62	7.7	26	16	18	3.4	8.2	6.0	0.1	14	-	-	149	231	132	-
	5-63	-	-	-	-	-	-	13[a]		-	-	-	-	270[b]	155[a]	-
-8A	5-63	-	-	-	-	-	-	8[a]	-	8.8	-	-	-	188[b]	81[a]	0.0
-9A	5-63	-	-	-	-	-	-	8[a]	-	6.0	-	-	-	153[b]	56[a]	0.0
-9R1	5-61	8.0	42	24	17	2.7	17	16	0.1	5.5	-	-	199	320	211	-
	5-63	8.3	39	21	25	2.2	15	15	0.1	21	0.05	47	219	276	183	-
-10E1	4-60	8.0	12	8.4	13	1.7	5.1	4.8	0.2	1.0	-	-	77	136	66	-
	5-63	-	-	-	-	-	-	6[a]	-	4.9	-	-	-	158[b]	56[a]	0.0
-12P1	7-58	7.9	58	40	37	3.8	66	26	0.2	16	0.06	44	334	455	308	-
	7-60	8.1	45	42	35	3.4	71	27	0.2	17	0.05	57	288	440	284	-
	6-63	8.2	94	25	36	3.9	80	28	0.0	18	0.07	51	351	494	337	-
-30N1	6-63	7.9	31	16	21	2.8	7.1	24	0.3	19	0.24	40	162	250	145	-

a - Laboratory Field Kit
b - Converted from Electrical Conductivity by the method of least squares

TABLE D-3
WASTE WATER QUALITY ANALYSES
FRESNO-CLOVIS METROPOLITAN AREA

Waste Discharge Units	Date Sampled Month and Year	pH	Mineral Constituents in Parts per Million (ppm)																
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_3)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)	Specific Conductance	Organic Nitrogen	Total Nitrogen	Organic Phosphate	Phenolic Material as Phenol
Fresno City Sewage Treatment Plant	4-63	7.4	14	8.5	34	10	16	20	0.3	0.9	0.39	31	177	263	70	1.6	435	18.3	18.5	11	-
Clovis City Sewage Treatment Plant	4-63	7.0	11	28	80	16	40	42	0.3	73	0.51	60	107	534	144	2.6	649	25.6	42.1	42	-
Pinedale Public Utility Commission	11-63	7.3	16	15	44	9.2	7.0	18	0.3	0.5	0.1	44	207	362	102	-	370	-	-	-	-
Pinedale Sewage Treatment Plant	11-63	7.3	26	12	33	10	7.0	15	0.3	0.5	0.01	58	199	360	114	-	360	-	-	-	-
Fresno County Sanitation District I	4-63	7.0	12	16	71	12	33	26	0.4	1.8	0.83	52	236	433	94	2.8	609	29.0	29.4	43	-
Fresno County Sanitation District II	4-63	6.9	11	20	83	15	33	35	0.5	1.3	0.79	44	244	456	110	3.6	765	39.7	40.0	45	-
Malaga Sewage Treatment Plant	6-63	7.4	74	12	121	19	49	92	-	52	1.7	53	313	633	232	-	975	-	-	-	-
Italian Swiss Colony	4-63	7.3	28	9.7	42	70	5.4	19	0.4	0.9	0.50	27	287	439	110	0.3	570	10.3	10.5	4.6	0.009
	10-63	4.8	52	52	102	920	177	41	0.4	2.0	0.2	58	366	1770	346	-	2850	-	-	-	-

Waste Discharge Units	Date Sampled Month and Year	pH	Mineral Constituents in Parts per Million (ppm)																	
			Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Silica (SiO_3)	Alkalinity (HCO_3)	Dissolved Solids	Total Hardness as $CaCO_3$	Alkyl Benzene Sulfonate (ABS)	Specific Conductance	Organic Nitrogen	Total Nitrogen	Organic Phosphate	Phenolic Material as Phenol
Alta Vineyards	10-63	4.6	36	22	20.0	360	56	12	0.4	2.1	0.1	48	0.0	556	180	-	1570	-	-	-	-
E & J Gallo Winery	11-63	3.7	52	48	60	3300	115	68	0.6	1.5	0.01	58	0.0	3700	328	-	3170	-	-	-	0.071
Fresno Meat Packing Company	11-63	7.1	43	33	228	27	9.1	244	0.2	1.6	0.01	72	538	1196	244	-	1150	-	-	-	-

PLATE 1

LOCATION OF
AREA OF INVESTIGATION

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

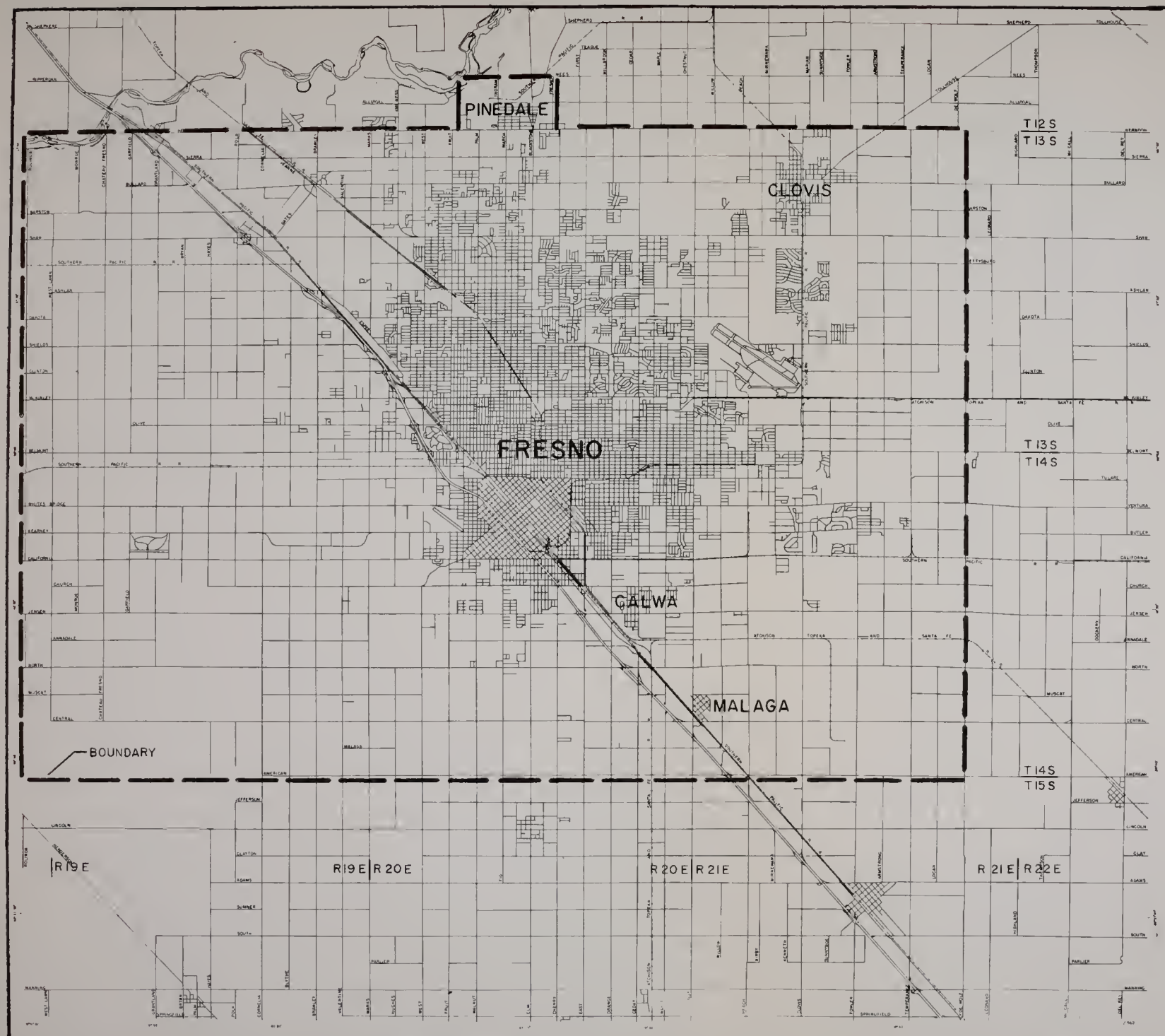
AREA OF INVESTIGATION

1963-64

SCALE OF MILES

1 0 1 2 3

PLATE 1



LOCATION OF AREA OF INVESTIGATION

STATE OF CALIFORNIA
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AREA OF INVESTIGATION

1963-64

SCALE OF MILES

1 0 1 2 3

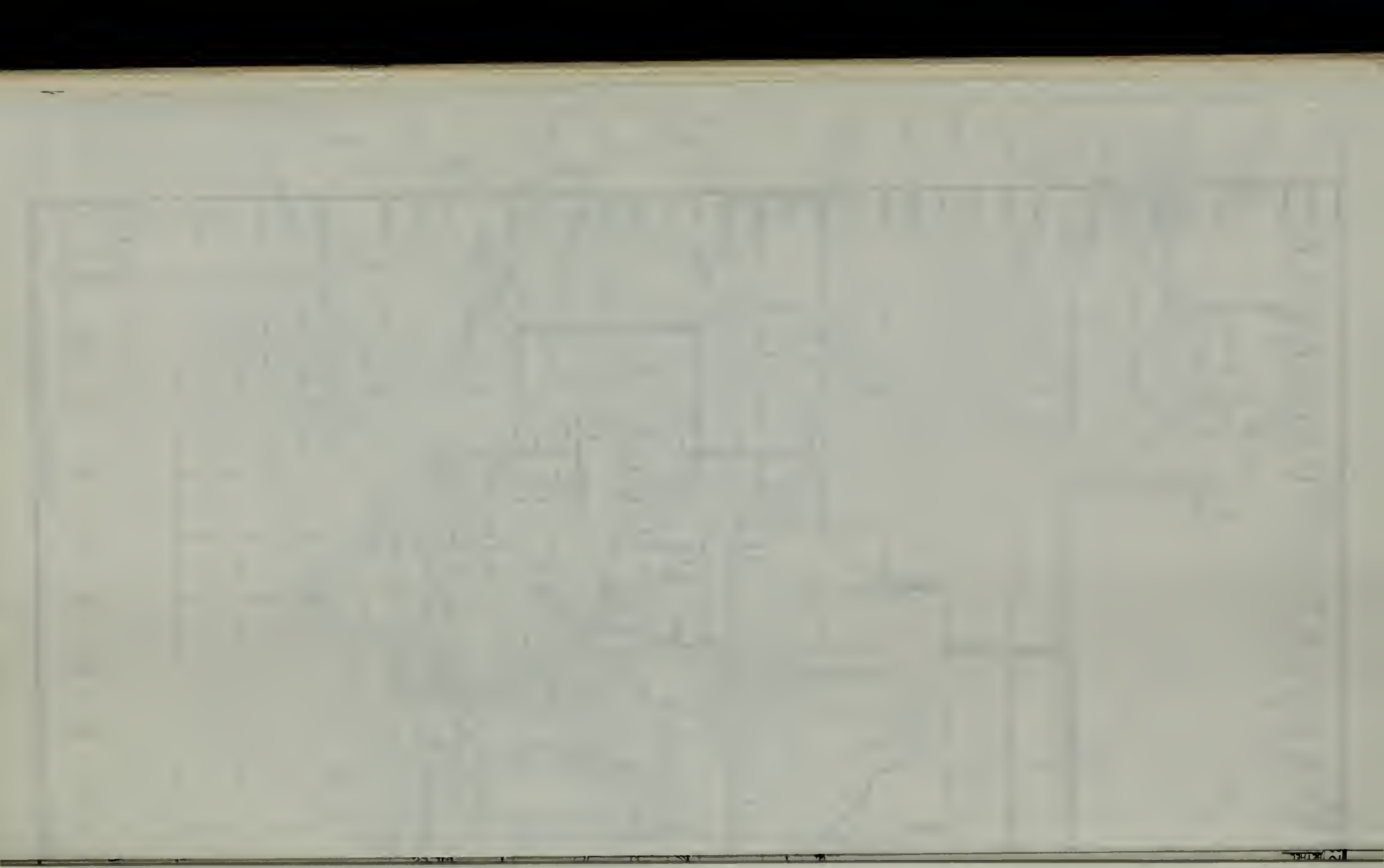
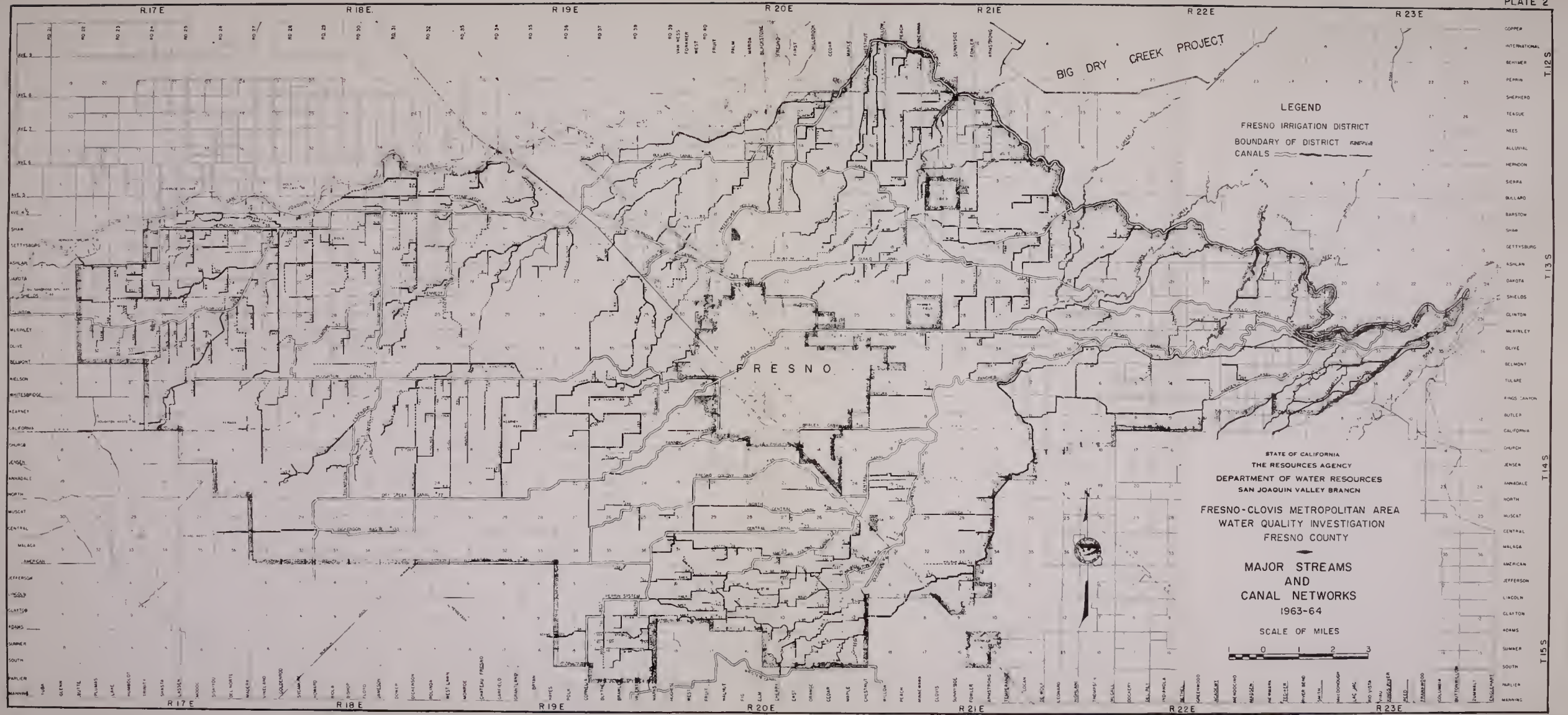


PLATE 2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R 18 E
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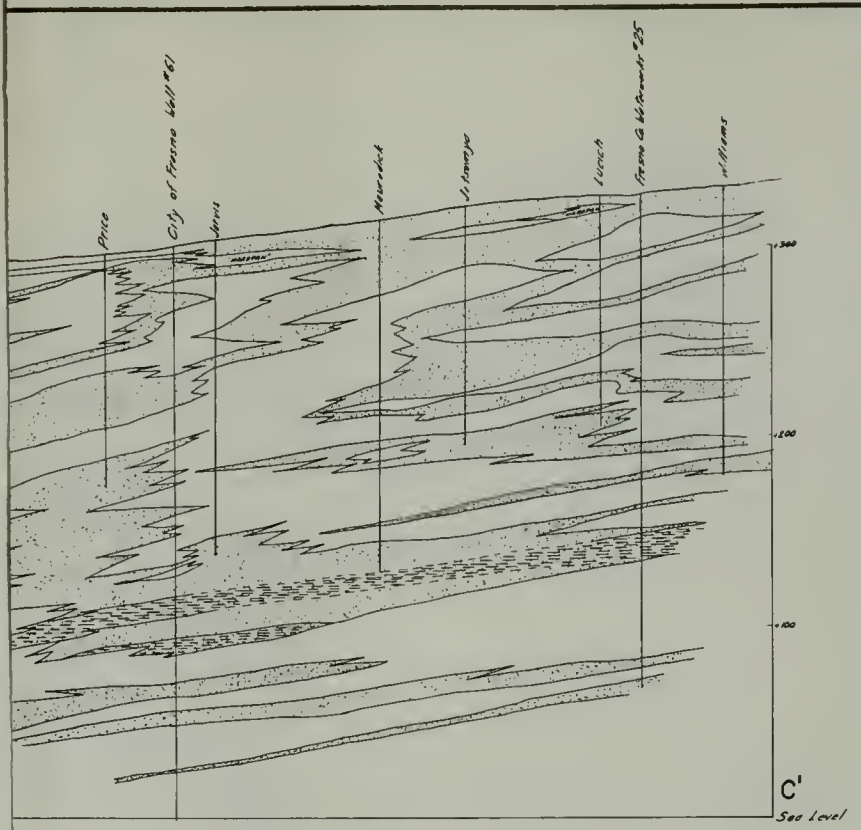
BIG DRY CREEK PROJECT
FRESNO
LEGEND
FRESNO IRRIGATION DISTRICT
BOUNDARY OF DISTRICT
CANALS
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH
FRESNO-CLOVIS METROPOLITAN AREA
WATER QUALITY INVESTIGATION
FRESNO COUNTY
MAJOR STREAMS
AND
CANAL NETWORKS
1963-64
SCALE OF MILES
0 1 2 3



NOTE: SEE PLATE 5 FOR LOCATION OF SECTIONS.

LEGEND

- CLAY
- SAND
- SANDY CLAY
- CLAYEY SAND
- GRAVEL
- CLAYEY GRAVEL

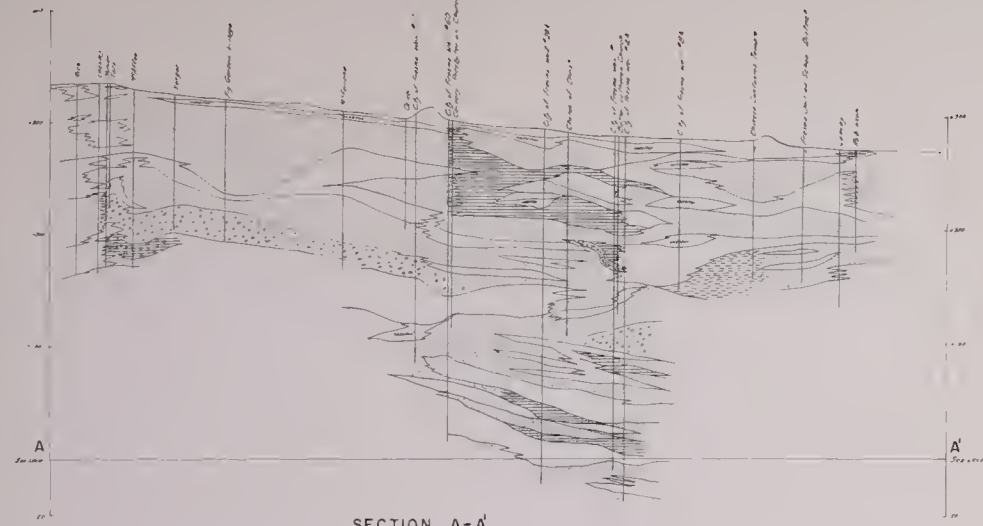
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

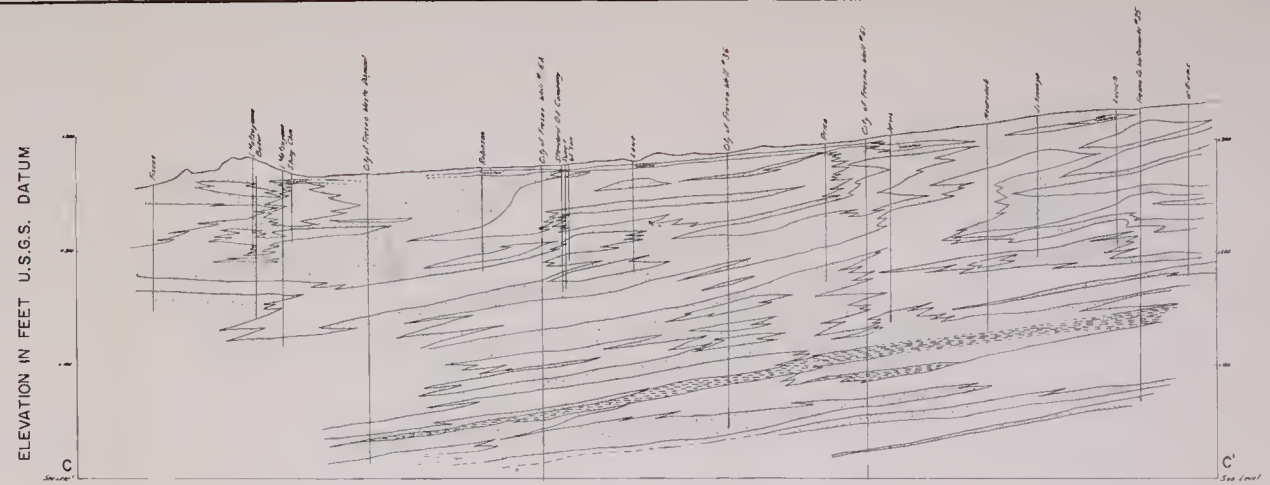
GEOLOGIC SECTIONS 1963

SCALE OF MILES

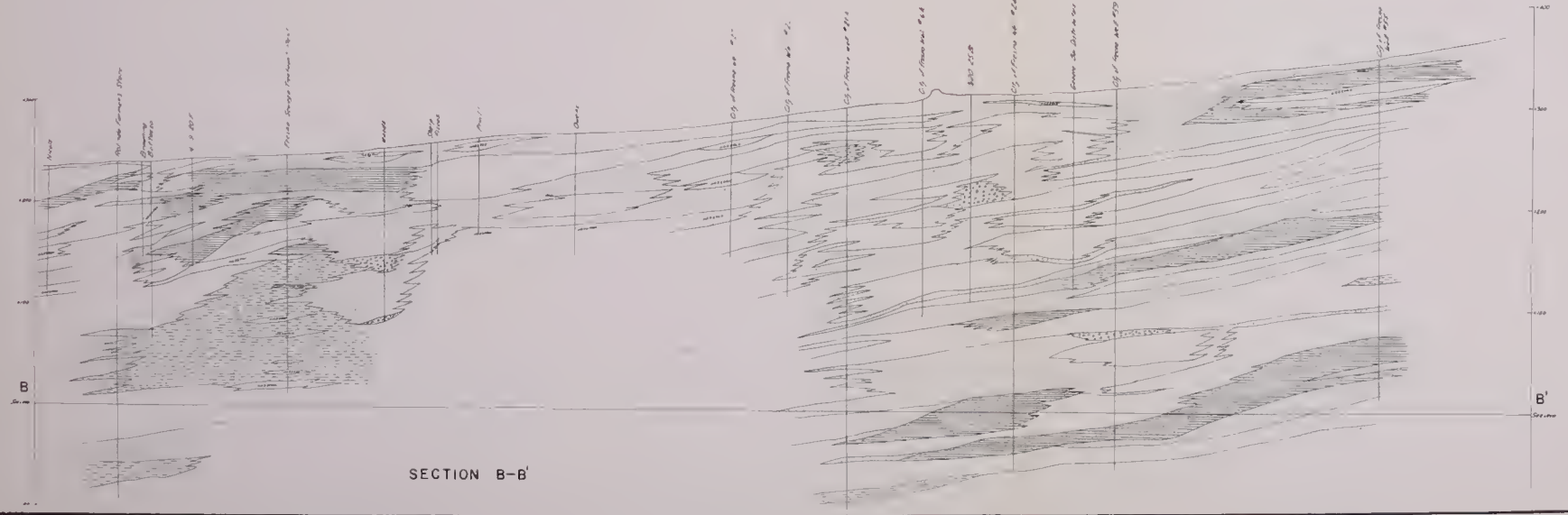
1 0 1 2



SECTION A-A'



SECTION C-C'



SECTION B-B'

NOTE SEE PLATE 5 FOR LOCATION OF SECTIONS.

LEGEND

- CLAY
- SAND
- SANDY CLAY
- CLAYEY SAND
- GRAVEL
- CLAYEY GRAVEL

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

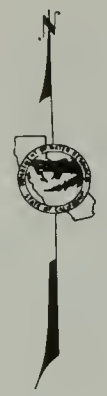
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

GEOLOGIC SECTIONS 1963

SCALE OF MILES

0 1 2

PLATE 4



LEGEND

SANDS AND SILTS OF THE "RIPPERDAN" DEPOSITION CYCLE

OLD ALLUVIUM–SANDS, SILTS, GRAVELS AND CLAYS–MAY HAVE "HARDPAN OR CLAYPAN"

YOUNG ALLUVIUM–SANDS, SILTS, GRAVELS AND CLAYS

STATE OF CALIFORNIA
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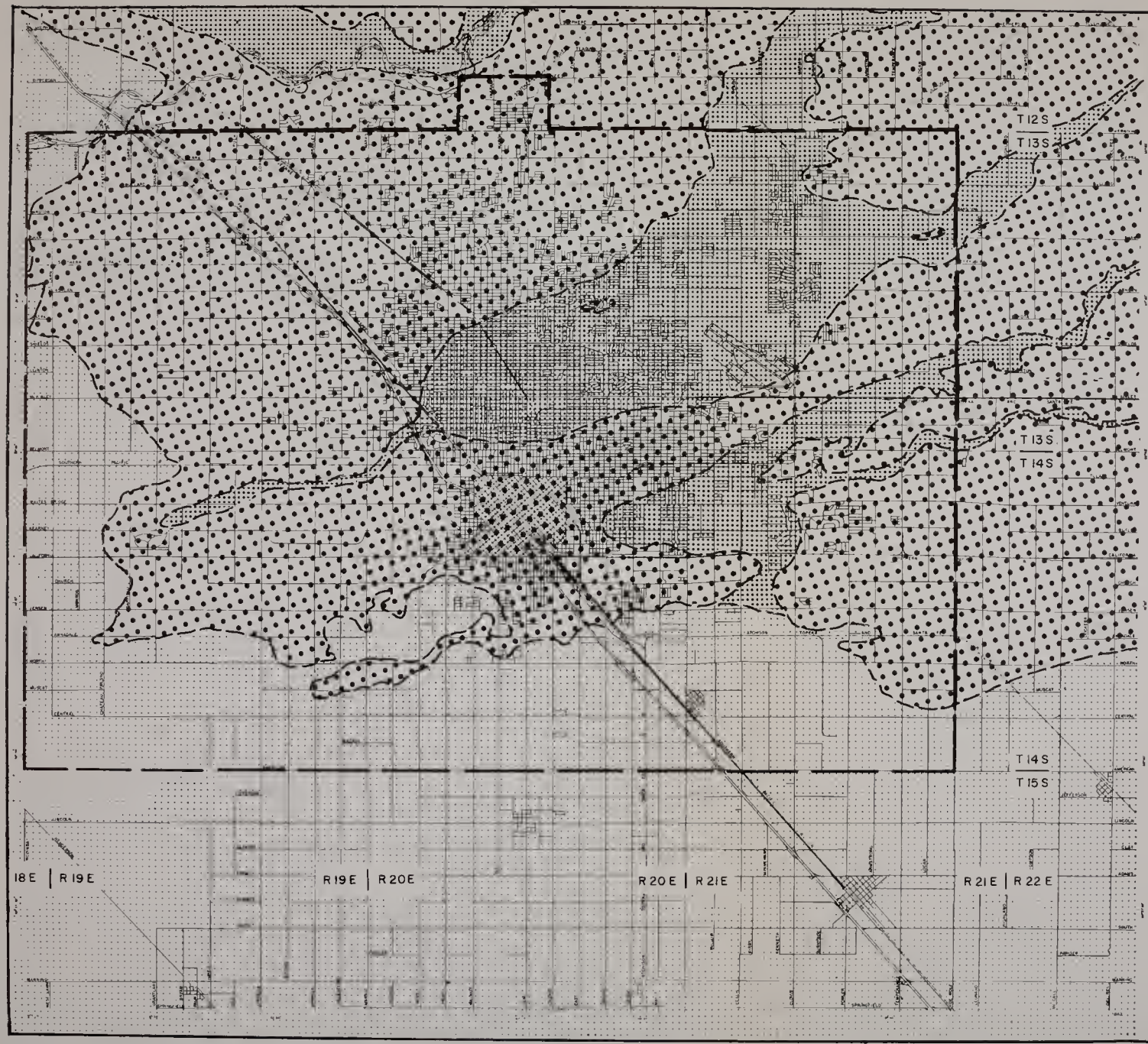
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

AREAL GEOLOGY

1963

SCALE OF MILES



LEGEND

- SANDS AND SILTS OF THE "RIPPERDAN" DEPOSITION CYCLE
- OLD ALLUVIUM–SANDS, SILTS, GRAVELS AND CLAYS–MAY HAVE "HARDPAN OR CLAYPAN"
- YOUNG ALLUVIUM–SANDS, SILTS, GRAVELS AND CLAYS

STATE OF CALIFORNIA
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DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

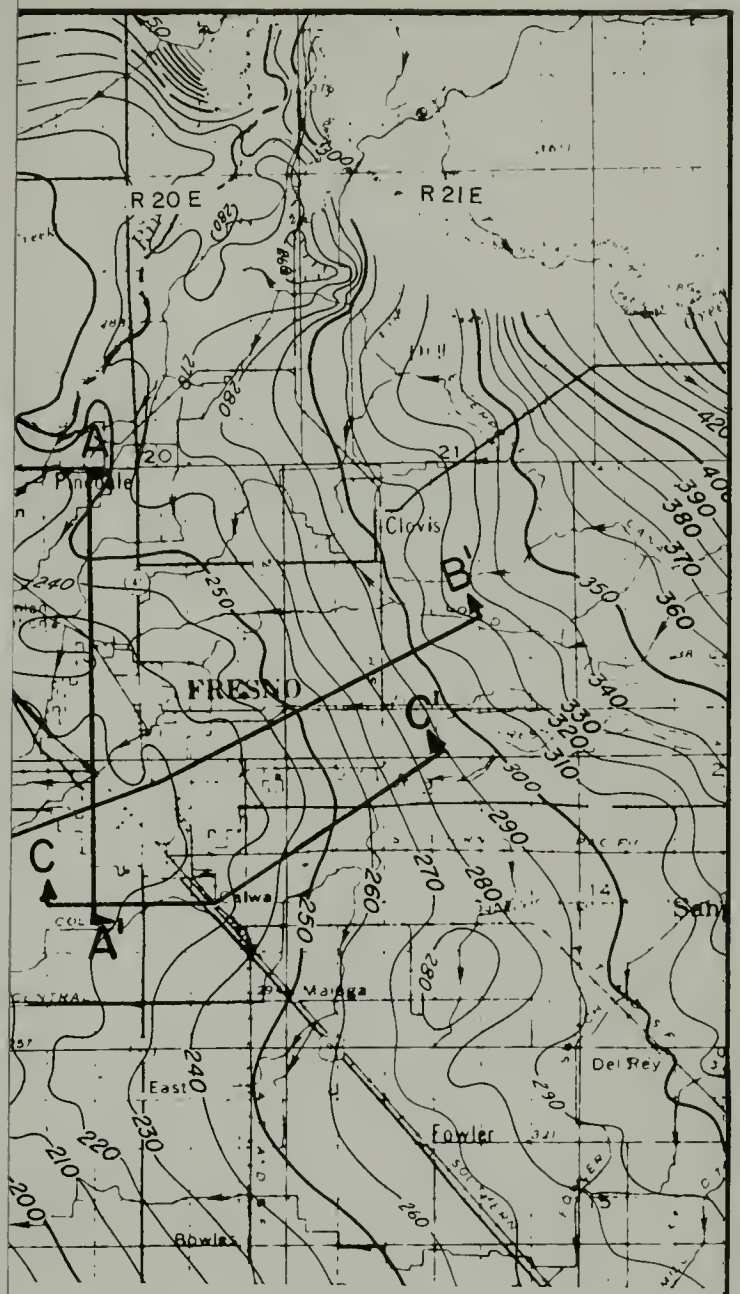
AREAL GEOLOGY

1963

SCALE OF MILES

1 0 1 2 3

PLATE 5



STATE OF CALIFORNIA

THE RESOURCES AGENCY

DEPARTMENT OF WATER RESOURCES

SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

LINES OF EQUAL ELEVATION OF GROUND WATER

SPRING 1963

SCALE OF MILES

2 0 2 4 6

PLATE 5

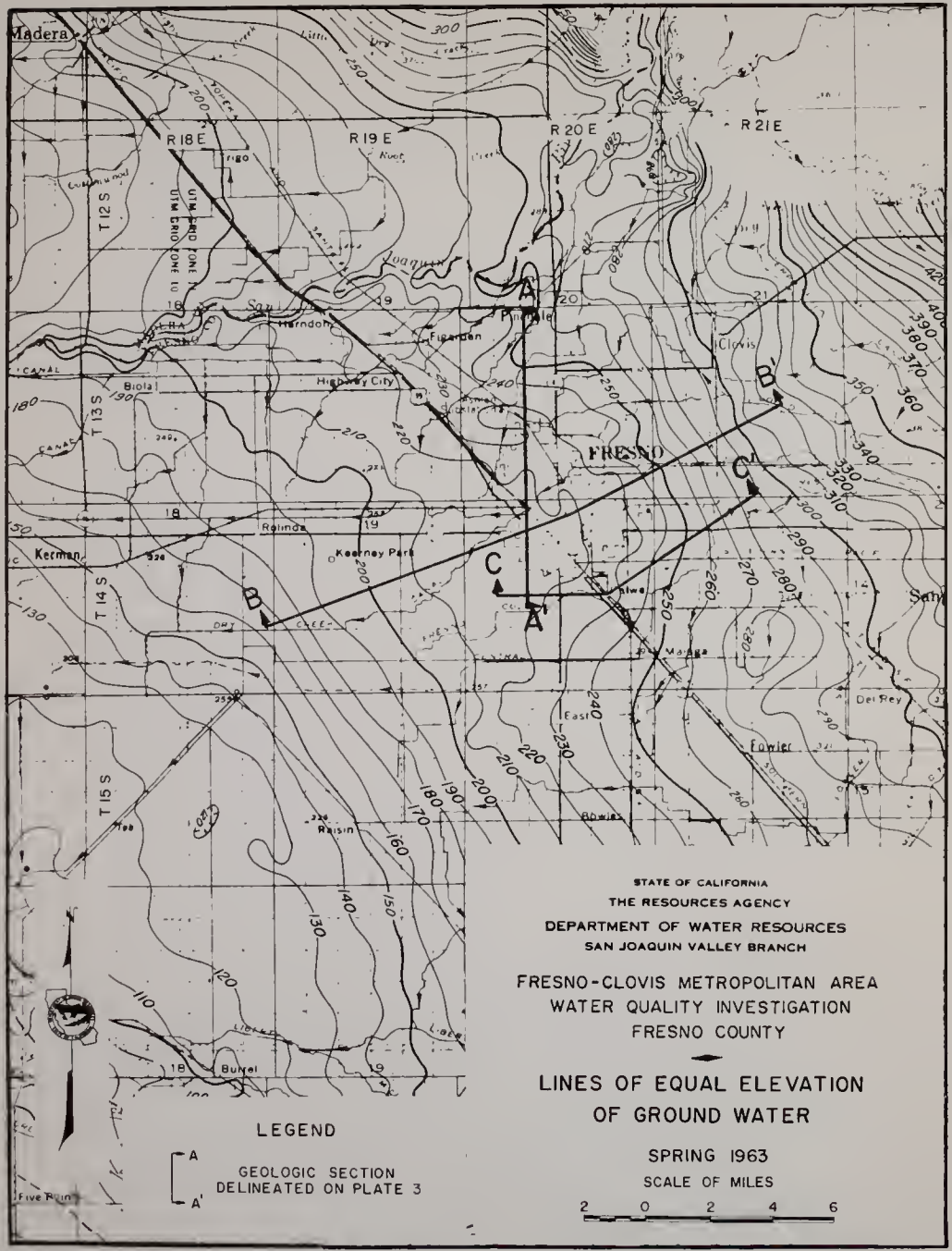

Madera
R18E
R19E
R20E
R21E
T12S
T13S
T14S
T15S
Friant
Herndon
Fresno
Clovis
Biola
Kerman
Kingsburg
Kearney Park
Selma
Malaga
Del Rey
Fowler
Raisin
Bullard
Five Points
A
A'
B
B'
C
C'
LEGEND
GEOLOGIC SECTION
DELINEATED ON PLATE 3
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH
FRESNO-CLOVIS METROPOLITAN AREA
WATER QUALITY INVESTIGATION
FRESNO COUNTY
LINES OF EQUAL ELEVATION
OF GROUND WATER
SPRING 1963
SCALE OF MILES
2 0 2 4 6

PLATE 6

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

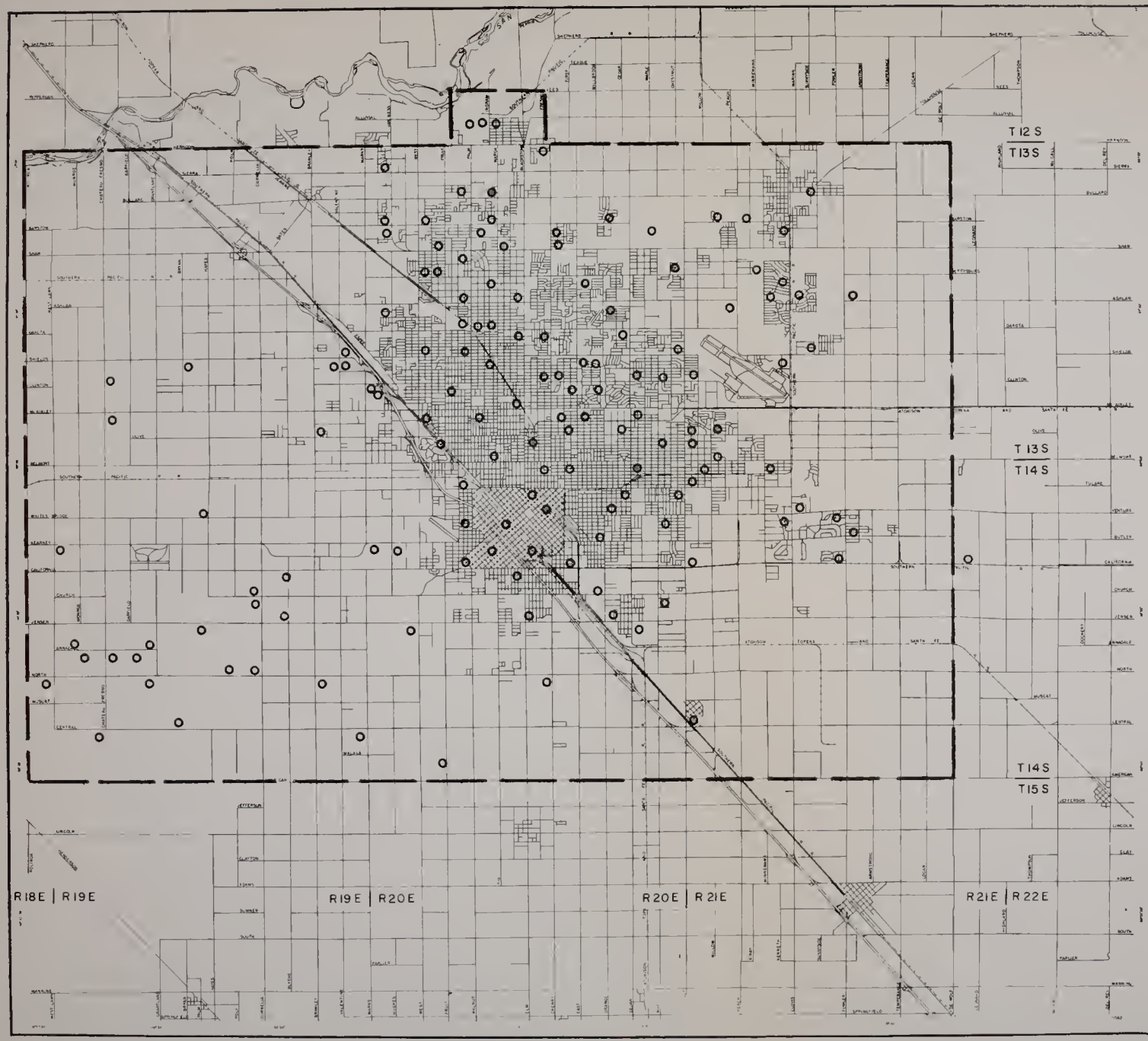
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

LOCATION OF WATER WELLS USED IN THE INVESTIGATION

1963-64

SCALE OF MILES

PLATE 6



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

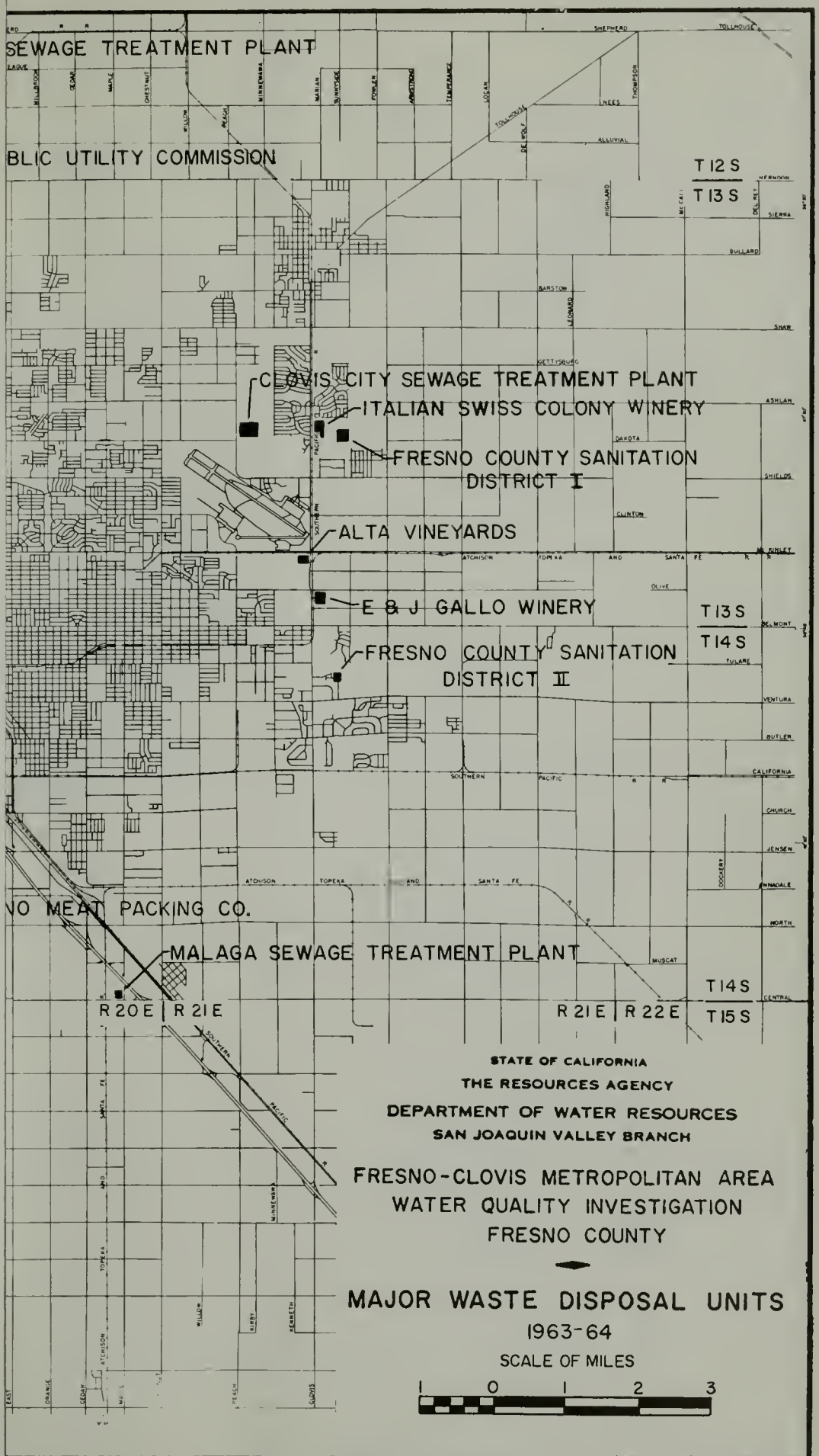
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

LOCATION OF WATER WELLS USED IN THE INVESTIGATION

1963-64

SCALE OF MILES

1 0 1 2 3



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

MAJOR WASTE DISPOSAL UNITS

1963-64

SCALE OF MILES

1 0 1 2 3

PLATE 7

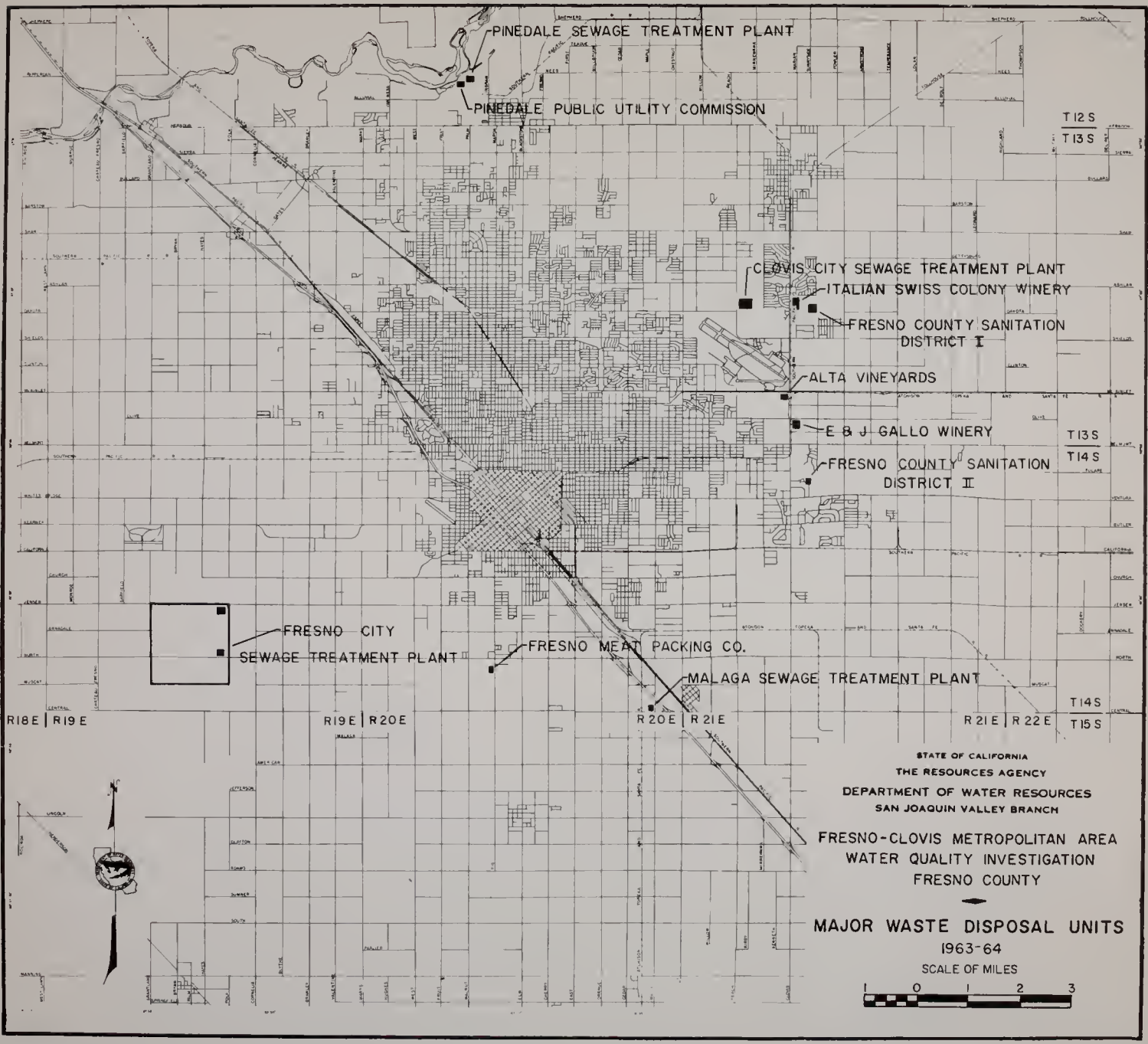

PINEDALE SEWAGE TREATMENT PLANT
PINEDALE PUBLIC UTILITY COMMISSION
T12S
T13S
CLOVIS CITY SEWAGE TREATMENT PLANT
ITALIAN SWISS COLONY WINERY
FRESNO COUNTY SANITATION DISTRICT I
ALTA VINEYARDS
E & J GALLO WINERY
T13S
T14S
FRESNO COUNTY SANITATION DISTRICT II
FRESNO CITY SEWAGE TREATMENT PLANT
FRESNO MEAT PACKING CO.
MALAGA SEWAGE TREATMENT PLANT
T14S
T15S
R18E | R19E
R19E | R20E
R20E | R21E
R21E | R22E
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH
FRESNO-CLOVIS METROPOLITAN AREA
WATER QUALITY INVESTIGATION
FRESNO COUNTY
MAJOR WASTE DISPOSAL UNITS
1963-64
SCALE OF MILES
0 1 2 3

PLATE 9

LEGEND

○	0-250	PARTS	PER	MILLION
△	251-500	"	"	"
□	501 <	"	"	"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

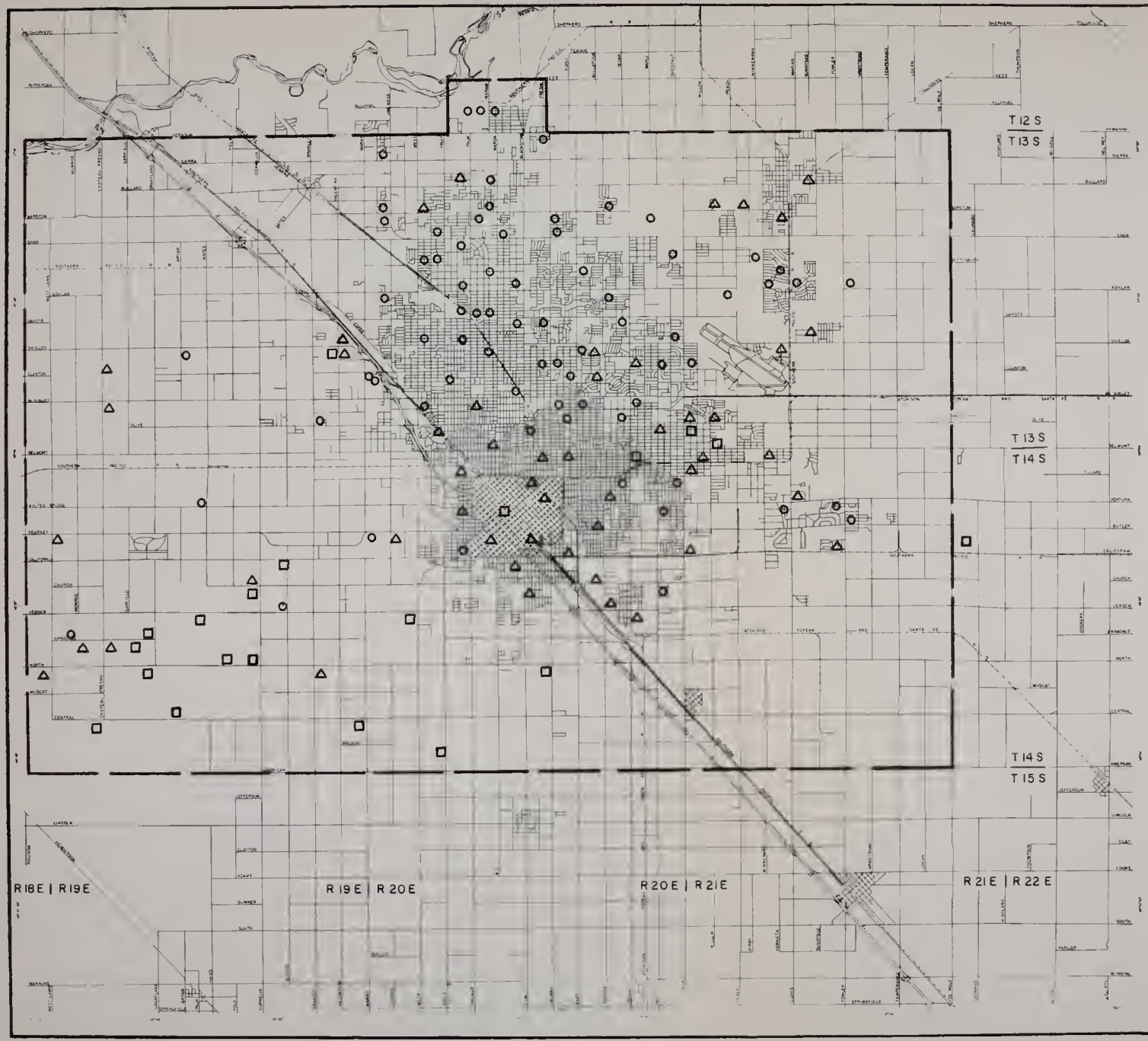
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

CONCENTRATION OF DISSOLVED SOLIDS

1963

SCALE OF MILES

PLATE 8



LEGEND

- ○ 0-100 PARTS PER MILLION
- △ 101-200 " " "
- □ 201 < " " "

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SAN JOAQUIN VALLEY BRANCH

FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

TOTAL HARDNESS AS $CaCO_3$

1963

SCALE OF MILES

1 0 1 2 3

LEGEND

○	0–15	PARTS	PER	MILLION
△	16–25	"	"	"
□	26–35	"	"	"

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

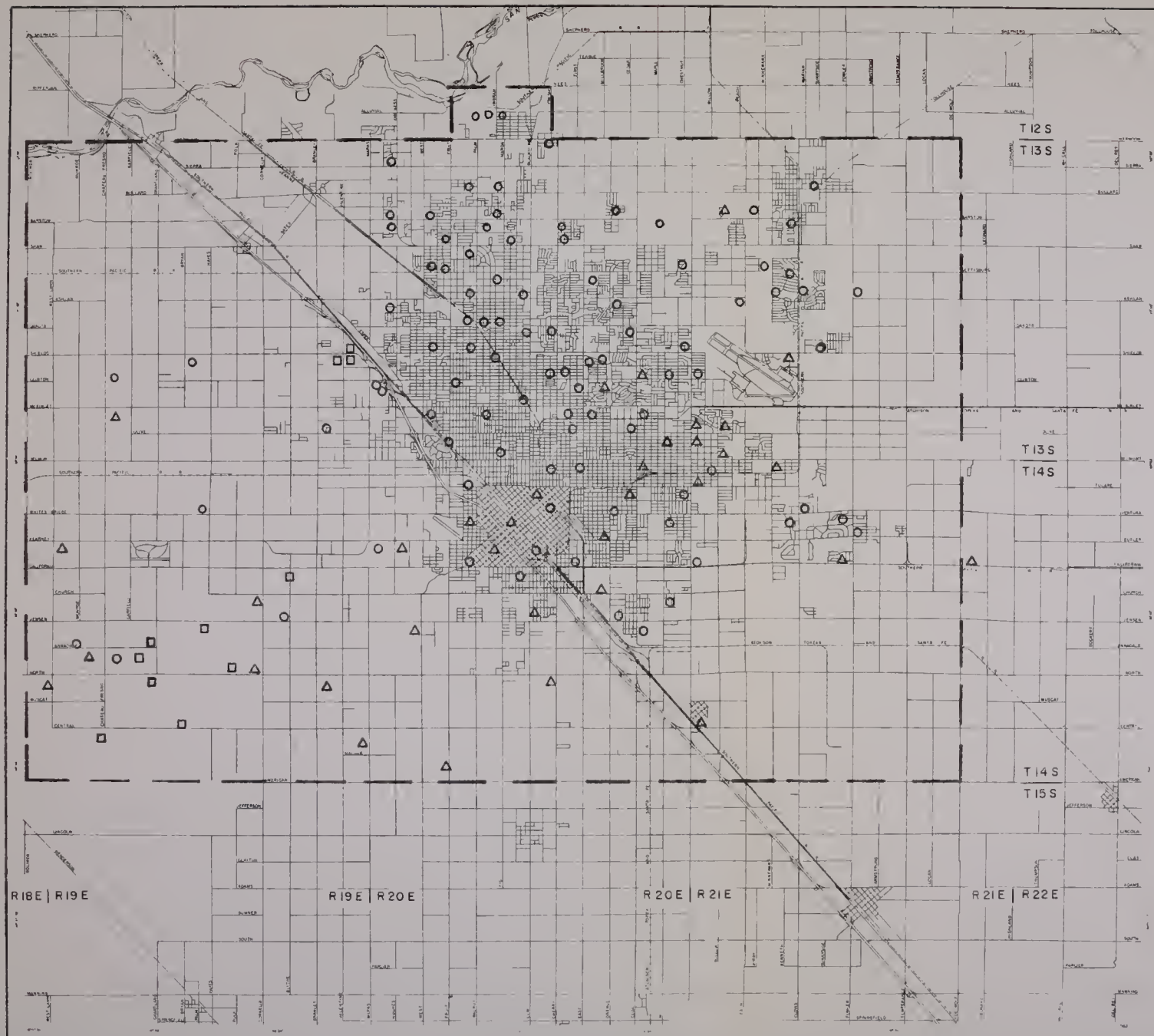
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

CONCENTRATION OF NITRATES AS NO_3

1963

SCALE OF MILES

1 0 1 2 3



LEGEND

○ 0-250 PARTS PER MILLION

△ 251-500 " " "

□ 501 < " " "

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

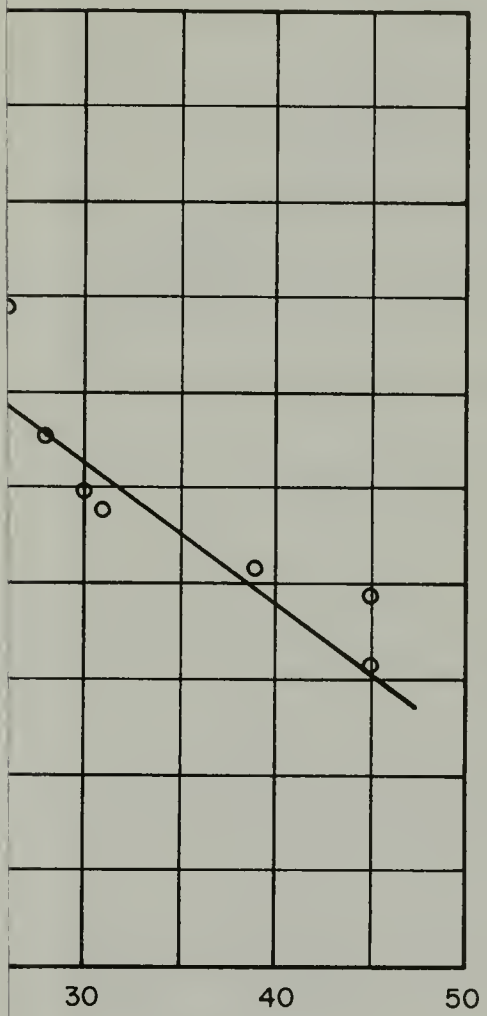
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

CONCENTRATION OF DISSOLVED SOLIDS

1963

SCALE OF MILES

1 0 1 2 3



ARTS PER MILLION

STATE OF CALIFORNIA
THE RESOURCES AGENCY
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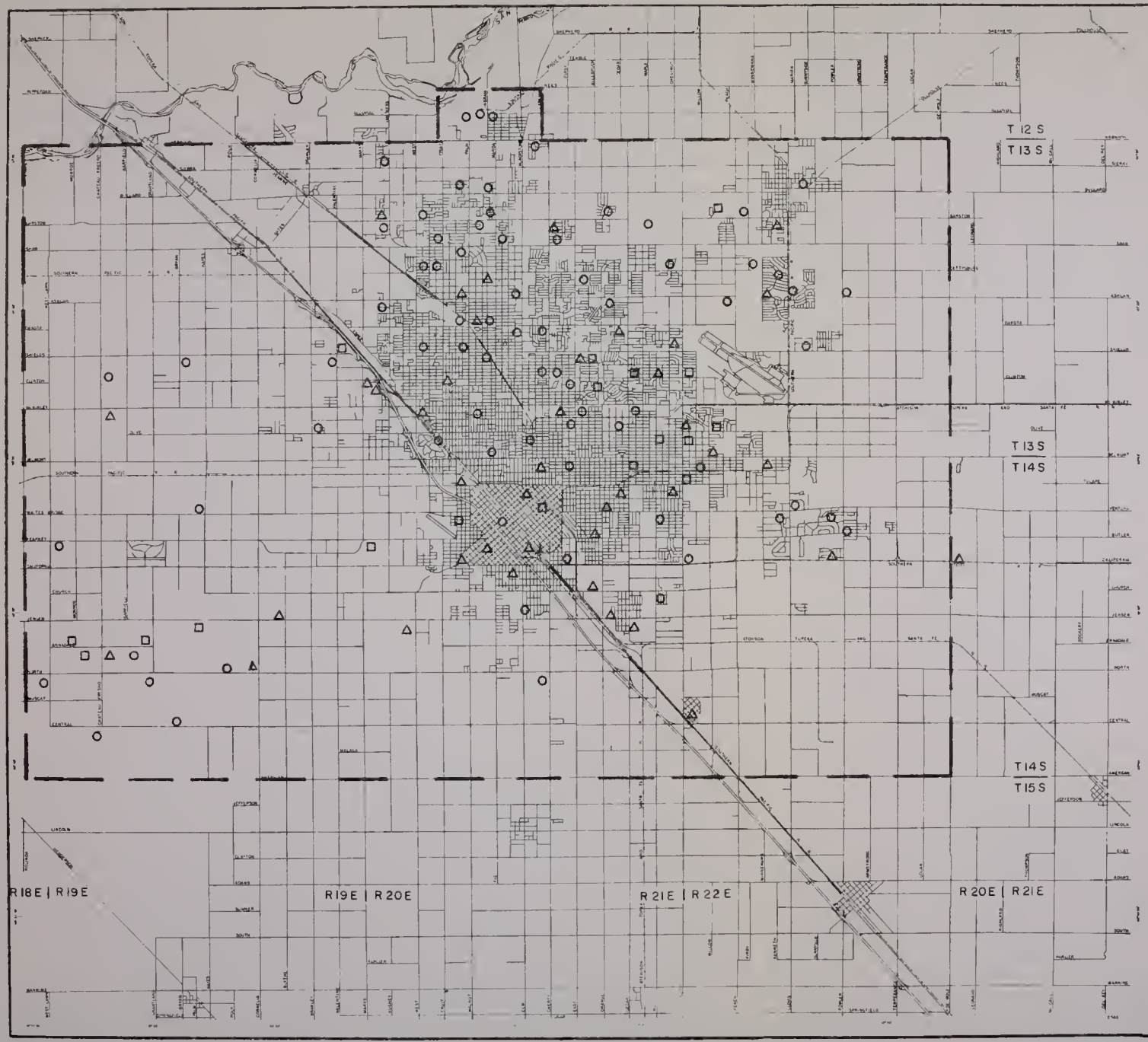
FRESNO-CLOVIS METROPOLITAN AREA
WATER QUALITY INVESTIGATION
FRESNO COUNTY

NITRATE VERSUS DEPTH RELATIONSHIP OF THE AREA SOUTHWEST OF THE FRESNO AIR TERMINAL

1963



LEGEND

- ○ 0–15 PARTS PER MILLION
- △ 16–25 " " "
- □ 26–35 " " "

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN VALLEY BRANCH

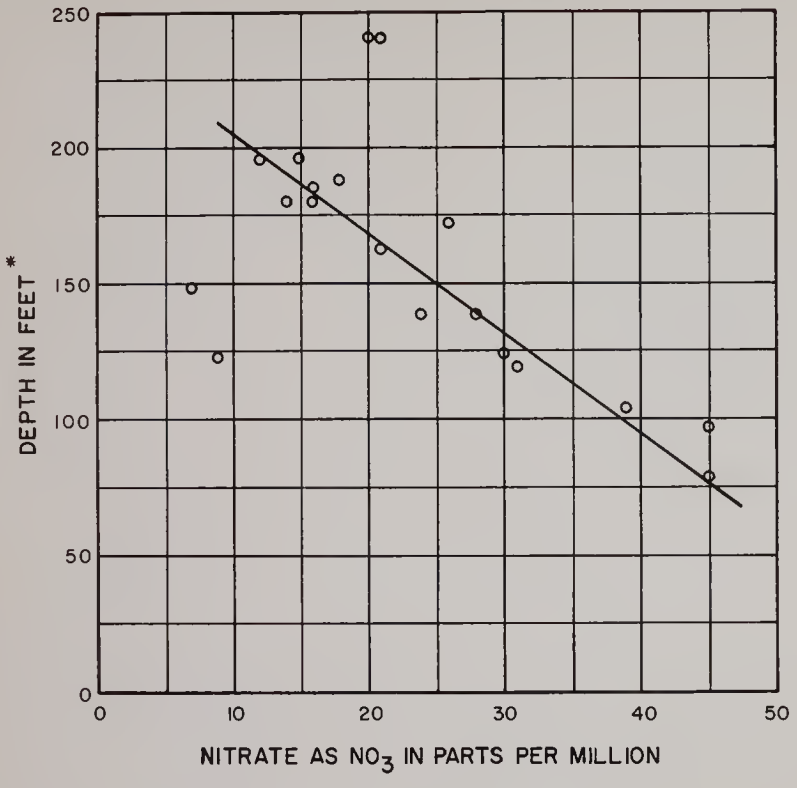
FRESNO-CLOVIS METROPOLITAN AREA WATER QUALITY INVESTIGATION FRESNO COUNTY

CONCENTRATION OF NITRATES AS NO_3

1963

SCALE OF MILES

1 0 1 2 3



*Depth measured from ground surface to uppermost casing opening

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FRESNO-CLOVIS METROPOLITAN AREA
WATER QUALITY INVESTIGATION
FRESNO COUNTY

NITRATE VERSUS DEPTH RELATIONSHIP OF THE AREA SOUTHWEST OF THE FRESNO AIR TERMINAL

1963

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